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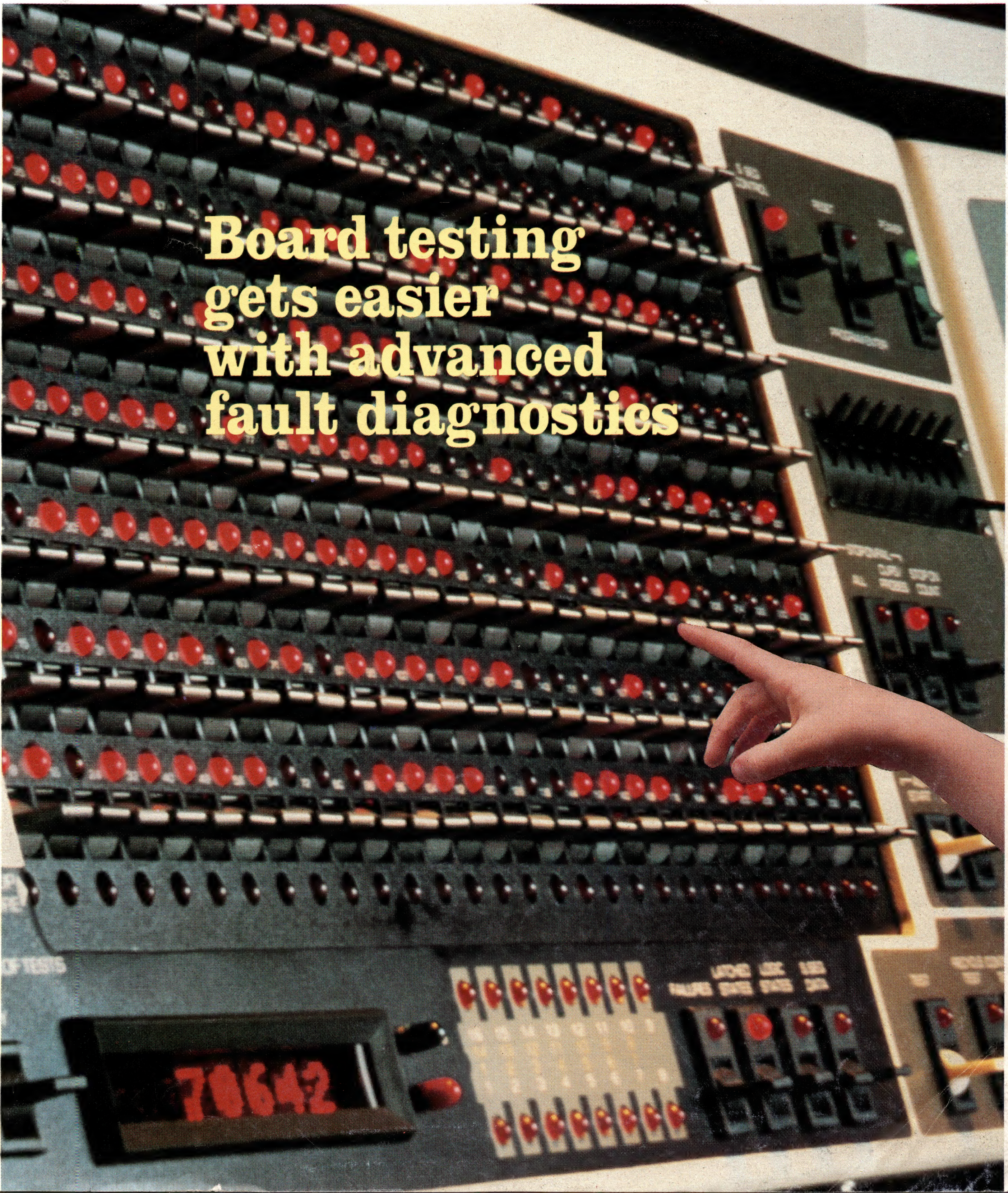
JUNE 21, 1980

Special Report:
Rf, GHz instruments soar in brainpower

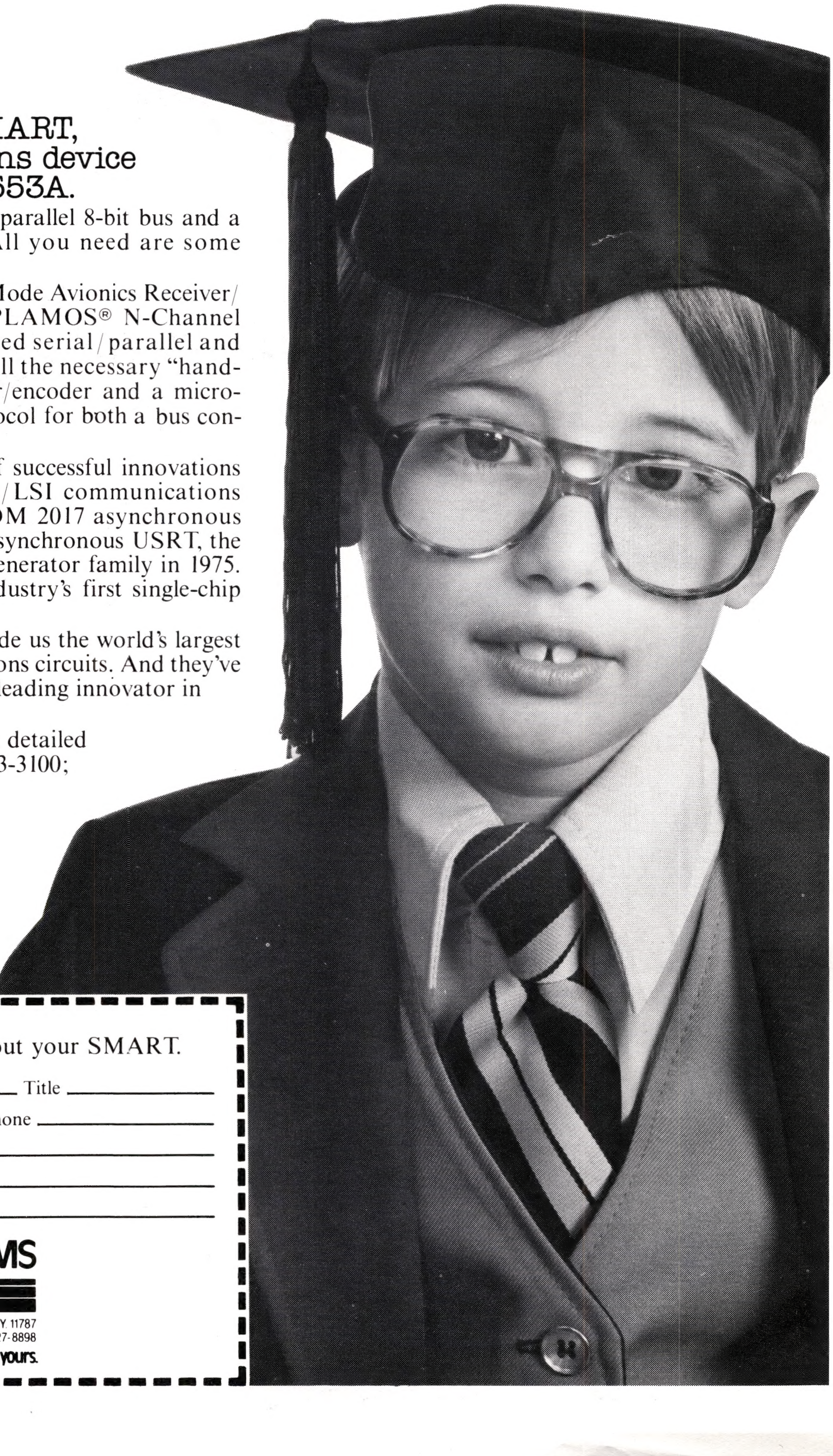
Four-part special:
Designing signal paths for high-speed data

ADC chip converts eight bits in less than 1 μs



Board testing gets easier with advanced fault diagnostics

To meet MIL-STD-1553A you're going to need some "SMARTs"



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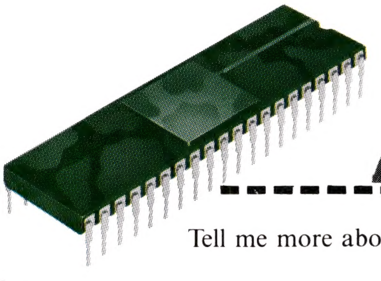

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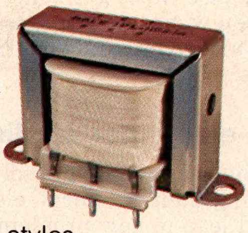

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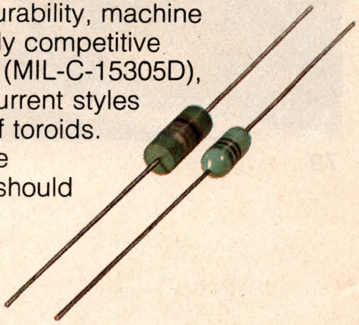

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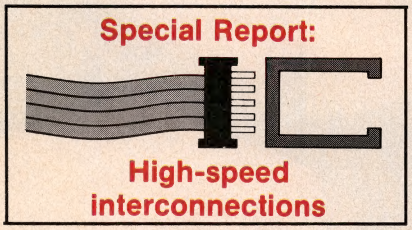
ElectronicDesign

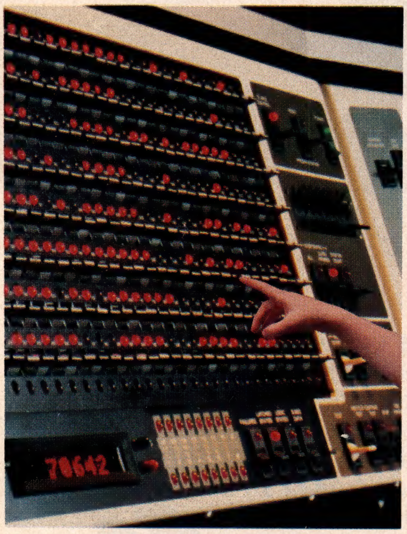
June 21, 1980 • Vol. 28 No. 13

Departments

5 Publisher's Memo
9 Editorial
13 Letters
15 Meetings
244 Index of Advertisers
246 Reader Service Card



63



79

News

23 Late News
31 Universal μP development system changes target quickly.
32 Support requirements shape up for 16-bit μPs.
33 μPs push data-comm as protocol decisions stall.
36 Ultra-small metallized-film capacitors use laser trimming.
38 Switcher designs advance despite 'imperfect' components.
41 Intel steps up μP competition with 32-bit chip set.
42 5.25-in. Winchesters boost density with thin-film media.
49 Washington Report
52A International Section

Technology

63 Special Report: Connections for high data speeds.

Moving high-speed digital signals from point to point in logic circuits requires interconnecting techniques that allow impedance matching and crosstalk control.

79 ATE finds dynamic faults in real time (cover).

Dynamic faults that escape ordinary automatic test equipment are pinned down by two powerful algorithms that compare a known-good board to the unit under test to isolate faults.

85 Monolithic 8-bit ADC matches micro speed.

With a conversion time of less than a microsecond, a self-contained successive-approximation analog-to-digital converter interfaces directly with microprocessors for maximum system throughput.

Design

95 Transmission-line methods speed 1-ns data along.

When switching rise times get faster than 1 ns, switch from conventional open wiring to impedance control by transmission-line technology and to crosstalk control by shielding and guiding the signal paths.

105 Conductive-elastomer applications abound.

Conductive elastomers can be the solutions to many problems—but not understanding their chemical, electrical and mechanical properties could lead to new problems.

113 Software eases a hard task—wire-routing ECL.

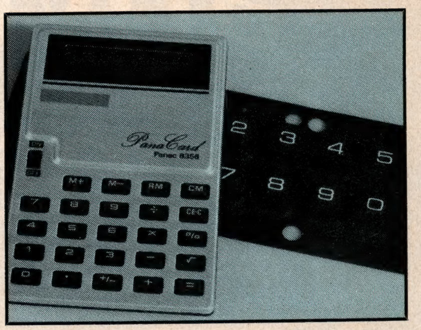
The automated placement and wire-routing of ECL for printed-circuit boards can upgrade existing computer designs with an economical investment of software and time.

119 Design equipment to run silent, run cool.

Designing electronic equipment that runs cool yet quiet requires more than choosing low-noise air movers. Aerodynamic design factors count.

129 Ideas for Design:

Thin-film resistor network stretches ADC performance.
Eliminate overrange 'hangover' in autozeroed ADCs.
ROM-resident software self-tests microcomputers.

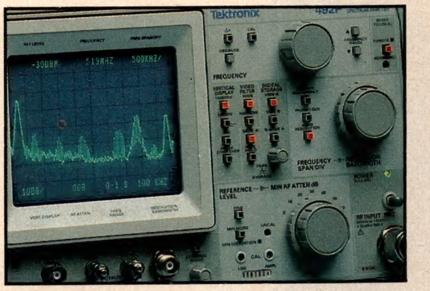

105

Products

141 Focus on microwave and rf instruments.

Spectrum and network analyzers, counters, signal sources and power meters place new-found intelligence and more sophisticated circuits at the convenience of users.

155 Analog Circuits: Data-acquisition system fits in 40-pin DIP.
156 Sample-and-hold amp acquires data in 1 μs.
158 Control system adds on minicassette drives.
160 Dual-channel amp matches precision specs.
162 Ceramic DIPs cut v/f converter costs.
168 Digital Circuits: CMOS octal circuits challenge bipolar.
170 Low-power LCD drivers handle dot displays.
174 Packaging & Production: Standard parts customize backplane.
176 ZIF side-guides reduce board stress and friction.
182 Instruments: 9-channel chart recorder corrects pen offsets.
188 Microsystems: Single-board computer uses dual clock.
200 Communications: Tester gives go/no-go to isolate faults.
195 Materials
196 Computers
210 Components
212 Subassemblies
218 Peripherals
220 Design Aids
226 New Literature


141

Coming in the July 5 issue:

Special Report on power semiconductors ... Tips on choosing a power source ... A new μC bus comes on the scene ... Designing an IC module to perform the Fast Fourier Transform ... Working with Hall-effect switches ... A new tool for digital circuit analysis.

Cover: Equipment photo courtesy of Fluke Automated Systems.

119,988 copies of this issue printed.

ELECTRONIC DESIGN (USPS-172-080) is published biweekly except 3 issues in July and May by Hayden Publishing Company, Inc., 50 Essex St., Rochelle Park, NJ 07662. James S. Mulholland Jr., President. Printed at Brown Printing Co., Waseca, MN, and Redmond Press, Denville, NJ. Controlled circulation postage paid at Waseca, MN, and Little Falls, NJ. Copyright © 1980, Hayden Publishing Company, Inc. All rights reserved. POSTMASTER: Please send form 3579 to ELECTRONIC DESIGN, P.O. Box 13803, Philadelphia, PA 19101.

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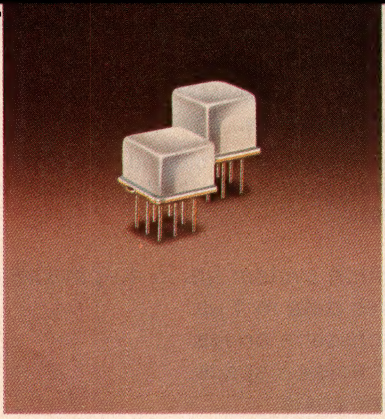

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Illustrator: Thomas Blaine

Editorial Offices:
50 Essex St., Rochelle Park, NJ 07662
(201) 843-0550, TWX: 710-990-5071
(HAYDENPUB ROPK)
Cable Haydenpubs Rochellepark

West Coast: 1307 S. Mary Ave., Suite 212
Sunnyvale, CA 94087. (408) 736-6667

8939 S. Sepulveda Blvd., Suite 414
Los Angeles, CA 90045. (213) 641-6544
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Publisher's Memo

As if design engineers don't have enough to do, a new area beckons for their expertise: production testing. Remember when automatic test equipment was strictly the province of the production engineer? That was before devices got too complex for anyone but a design engineer to set up tests for the completed product. And, the testability of a design is becoming almost as important as performance-raising innovations.

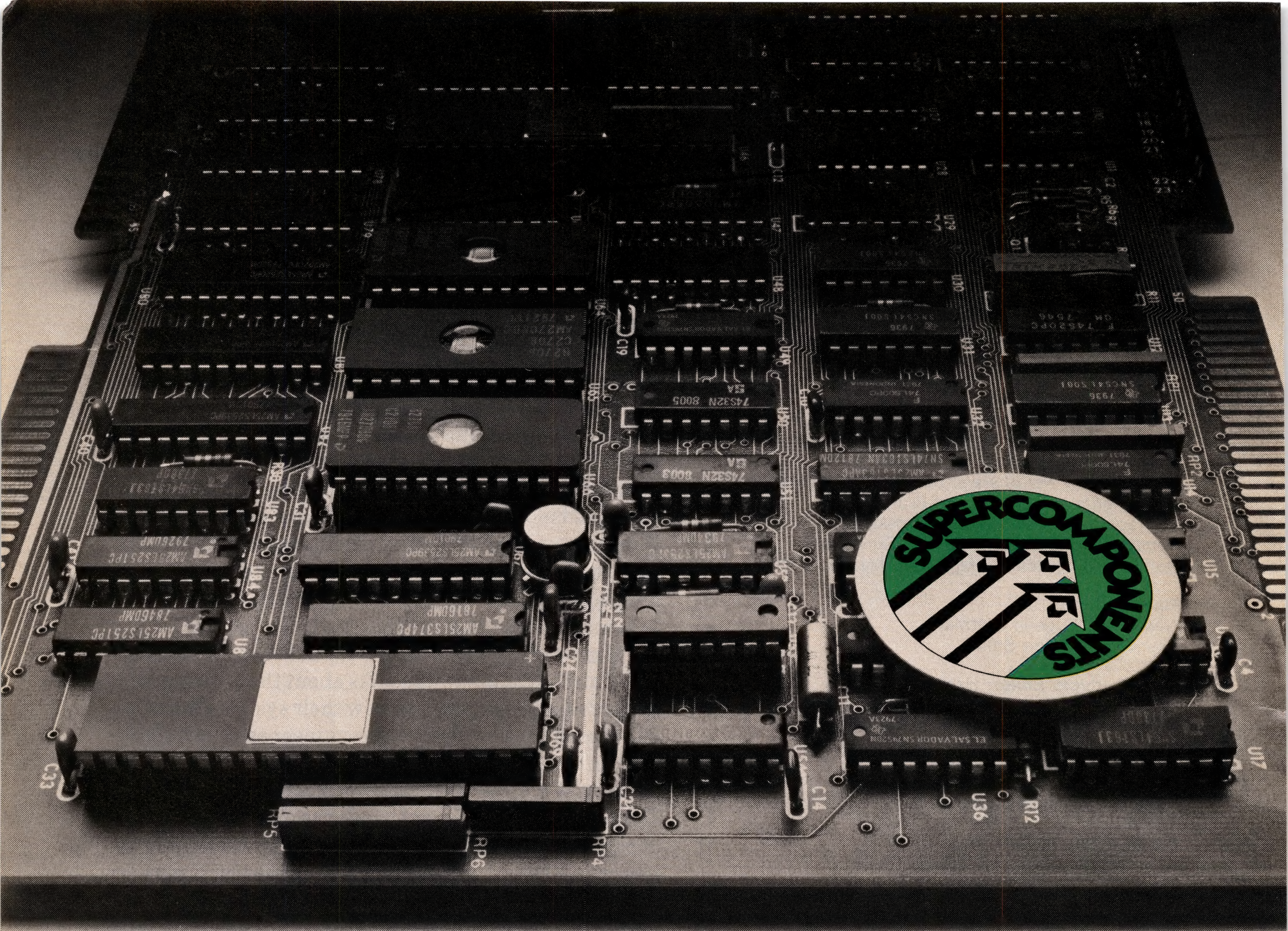
Instruments Editor Jonah McLeod points out that the Fluke tester on this issue's cover is part of a new generation of testers for LSI-based boards that will command more and more of a designer's attention. The Fluke tester, with its ability to pinpoint sources of soft failure on μP-based boards, is programmed to select the most appropriate route to fault identification—information that the designer can best provide.

"Almost everyone I confer with at Fluke, Tektronix, HP, Fairchild and the like talks about the growing role of the design engineer, and how their systems have to be tailored to allow the design engineer easy entry into the test-setup procedures," says McLeod.

Galen Wampler, Instruments Market Specialist at Dataquest (Cupertino, CA) adds the view that computer-aided design techniques will increasingly be tied into ATE not only for developing the test programs but even for deciding whether the product being developed is testable. At the same time, growing at about a 25% compound annual growth rate, board testers have become a veritable hotbed of activity in an area (instruments) where 10 to 15% growth rates usually bring smiles.

In the face of all that growth, ATE manufacturers will be turning more and more to design engineers for feedback on what they need. And to provide the answers, design engineers will be enlarging their scope to include more and more of the total equipment-production process.

Larry Altman



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Editorial

Reviving productivity—I

Shrinking U.S. productivity weighs heavily on everybody's mind these days. Outputs are down, other nations are out-competing us, service and government jobs take up 70% of the work force, and—most disheartening of all—the American worker shows increasing signs of not believing in work.

Fifteen years ago, about half the American workers found some personal fulfillment from their jobs. Today, less than one-quarter do, according to Daniel Yankelovich, president of a highly regarded public-opinion research house and a leading commentator on work attitudes. Two decades ago, 58% thought that hard work paid off. Now, only 43% think so. Of all Americans working today, a mere 13% find working more meaningful—much less more important—than leisure-time activities.

Instead of taking the conventional route to spurring national productivity—stimulating capital investment and new technology—Yankelovich sees motivating the human resources as the key. But not with conventional incentives, like more money. Money simply isn't persuasive in times of high inflation, when people sense that the national standard of living has stopped rising, and when a pervasive feeling exists that job security should be a guaranteed right.

Correctly rejecting the notion—born out of frustration—that a good depression will bring back old insecurities and so revive the American work ethic, Yankelovich calls for recognizing the broad diversity of workers, analyzing how they've changed, and then tailoring a system of customized, individual incentive programs. This sounds good—up to a point.

For one thing, what happens when a worker changes jobs, and then must adjust to a completely new set of "customized" incentives? What happens when those responsible for formulating and maintaining the incentives leave for greener pastures? Will the replacements continue the established incentives program or will they feel compelled to add their own personal touches?

Furthermore, the cost of such programs, which would inevitably lead to creating new industrial bureaucracies of highly paid specialists, could easily prove greater than simply providing better-than-inflation wage hikes.

Perhaps it would be better to learn from the experiences of other, more productive societies—Japan's, for instance.

Reviving productivity—II

Japan, as is well known, is a phenomenal success story. It stands second to none in producing steel, ships, photographic equipment, cars, bicycles and motorcycles—and its electronics industry is coming on fast. But there's a lot more to the story.

Unemployment usually runs at only about 1 or 2%. The crime rate is the lowest of all industrial nations. Personal savings and capital investments are double those in the U.S. And strikes claim only one-eighth the days lost in the U.S.

Obviously, Japanese management is very successful—productivity offers telling evidence. But as the other figures imply, productivity is just one measure of success.

Much of the credit for both strong productivity and employee well-being is given to a centuries-old practice that is still predominant: *Sushin koyo*, or lifetime employment. Within the practice, employees are hired right out of school. Executives usually come up through the ranks, not from the outside. And intercompany mobility is virtually nonexistent.

Sushin koyo stimulates and encourages productivity and innovation because workers know that procedural improvements, automation or new equipment will not bring layoffs. They know that only transfers within the company can result—quite possibly in the form of a promotion.

While it may not be practical to transfer one nation's customs to another, the benefits of a management philosophy that builds incredibly high employee morale cannot be denied. Nor can other Japanese business practices that have stood the test of centuries.

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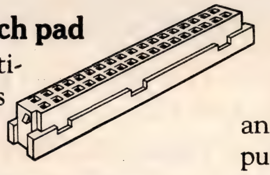
The iSBX™ launch pad



The key to Multimodule flexibility is the iSBX bus—the first physical/electrical interface for direct on-board expansion of iSBC systems. Available on all future Intel single board computers, the iSBX bus assures you of compatibility between iSBCs and the emerging Multimodule product line.

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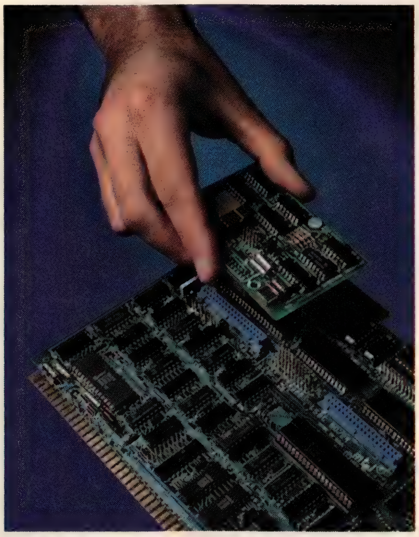

Two new iSBC™ command modules

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A small step for microcomputers

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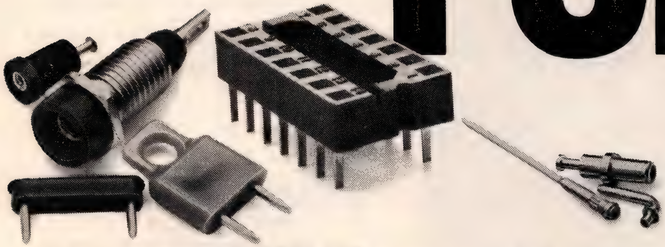

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CIRCLE 7

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Letters

One comparison has its signals crossed

In his article "A Signal Processor Fast Enough to Do Real-Time Voice-Band" (Feb. 15, 1980, p. 86), David Millet made two incorrect references to AMI's S2811 signal-processing peripheral.

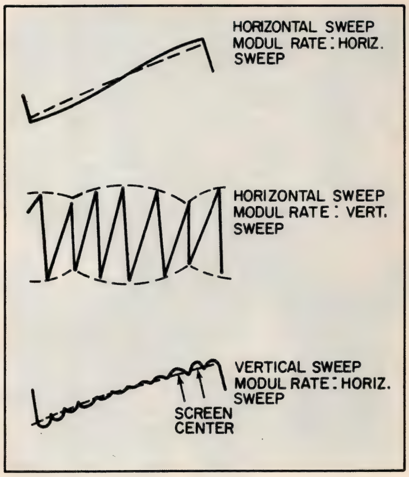
He states that the S2811 has a parallel-serial multiplier. The multiplier is fully parallel, just like that in the μPD7720. The S2811 advanced product description has been available for some time. The facts also appear in my article, "Programmable Signal-Processor LSI Rivals Analog-Circuit Filters," in the very same issue (p. 137)!

The claim that the S2811 takes 1.5 ms to perform a 32-point complex multiplication is also incorrect. This is the time it takes to perform a complete 32-point complex and expandable FFT, including conditional array scaling and all the necessary data manipulation. By dispensing with the conditional array scaling and by not expanding the FFT—either through time-sharing the processor (for minimum hardware) or paralleling multiple S2811s (for maximum speed)—the FFT could be performed in less time. The 32-point complex multiplication, which is a subroutine in this FFT, is in fact executed in approximately 0.4 ms, compared with 0.7 ms for the μPD7720.

It is misleading to compare the relative powers of the two devices by comparing cycle speeds, since the S2811 instruction cycle is a full memory-to-memory (ready-modify write) cycle, whereas the μPD7720 cycle is not. The power of the S2811 cycle is illustrated by the second-order digital filter section, which requires four multiply and accumulate operations and two move operations. The operations are performed in five cycles in the S2811; the μPD7720 requires nine cycles.

Gwyn Edwards
Telecomm Applications Engineer
American Microsystems Inc.
3800 Homestead Rd.
Santa Clara, CA 95051

Swept away



Looking for the sweep signals on p. 165 of the story on Hewlett-Packard's new color-graphics computer (May 10)?

Thermal printer works, in other words

A report on the new Gulton Microplot 44 Thermal Printer appeared in your April 12 issue (p. 238). It contained the following misconception of how the Micro-

(continued on page 16)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Editor, Electronic Design, 50 Essex St., Rochelle Park, NJ 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld upon request.

When you need illuminated switches, or more than illuminated switches...

Dialight is the first place to look. We make just about any kind of illuminated push button switch that anyone could want . . . Single lamp, dual lamp, neon, incandescent, LED lighted, you name it.

Perhaps you're looking for snap action switches with silver or gold contacts, or wiping action switches with gold contacts for low level application.

And if you're looking for rear panel or front bezel mounting switches, switches with momentary or alternate actions, or high quality switches for computer applications, we have them.

You'll find that Dialight switches are not only available at a reasonable price, they're also available with some very attractive features. Lamp removal is from the front so you don't have to remove an entire switch just to change a lamp. And you never have to use anything more complicated than your fingers for replacement or installation.

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CIRCLE 8

Meetings

Power Engineering Society Summer Meeting, July 13-18. Radisson Hotel, Minneapolis, MN. IEEE, 345 E. 47 St., New York, NY 10017.

Nuclear and Space Radiation Effects Conference, July 15-18. Cornell Univ., Ithaca, NY. IEEE.

Quartz Crystal Conference, Aug. 12-14. Radisson Muehlebach Hotel, Kansas City, MO. K-N Enterprises, Inc., 630 S. Rogers Rd., Olathe, KS 66061.

Intersociety Energy Conversion Conference, Aug. 18-22. Olympic Hotel, Seattle, WA. IEEE.

Engineering in the Ocean Environment, Sept. 8-10. Olympic Hotel, Seattle, WA. IEEE.

International Congress on Transportation Electronics, Sept. 15-17. Hyatt Regency, Dearborn, MI. IEEE.

European Solid-State Device Research Conference (ESSDERC '80), Sept. 15-18. University of York, York, England. IEEE.

Optical Communication European Conference, Sept. 15-19. University of York, York, England. IEEE.

Electromagnetic Compatibility, Conference, Sept. 15-19. University of Southampton, Southampton, England. IEEE.

International Symposium on Subscriber Loops and Services (ISSLS '80), Sept. 15-19. Bayericheoss, Munich, W. Germany. IEEE.

International Fiber Optics and Communications Exposition, Sept. 16-18. Hyatt Regency, San Francisco, CA. Information Gatekeepers, Inc., 167 Corey Rd., Suite 111, Brookline, MA 02146.

Western Electronic Show and Convention (WESCON), Sept. 16-18. Anaheim Convention Center, Anaheim, CA. IEEE.

Broadcast Symposium, Sept. 17-19. The Washington Hotel, Washington, DC. IEEE.

Mid-Atlantic Business & Home Computer Show, Sept. 18-21. D.C. Armory/Starplex, Washington, DC. National Computer Shows, P.O. Box 678, Brookline, MA 02147.

International Broadcasting Convention, Sept. 20-24. Metropole Conference Center, Brighton, England. IEEE.

Compcon Fall '80, Sept. 23-25. Capitol Hilton, Washington, DC. IEEE.

European Conference on Optical Systems and Applications, Sept. 23-25. Utrecht, The Netherlands. IEEE.

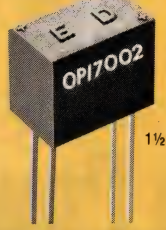
Joint Power Generation Conference, Sept. 28-Oct. 2. Hyatt Regency Hotel, Phoenix, AZ. IEEE.

Holm Conference on Electrical Contacts, Sept. 29-Oct. 1. Palmer House, Chicago, IL. IEEE.

Electronics and Aerospace Systems Conference, Sept. 29-Oct. 1. Sheraton National Hotel, Arlington, VA. IEEE

Applied Superconductivity Conference, Sept. 29-Oct. 2. Sweeney Convention Center, Santa Fe, NM. IEEE.

Industry Applications Society Meeting, Sept. 29-Oct. 3. Stouffer's Inn, Cincinnati, OH, IEEE.



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HIGH VOLTAGE ISOLATION!

TRW Optron
OPTICALLY COUPLED ISOLATORS

NEW OPI 7000 SERIES OFFERS LOW COST, HIGH VOLTAGE ISOLATION

TRW Optron's new OPI 7000 series optically coupled isolators meet the designer's requirements for high voltage isolation, yet at a low cost.

The new series is available from stock and includes OPI 7002, OPI 7010, OPI 7320, and OPI 7340 types.

These devices feature input-to-output steady state isolation voltage of greater than 6000 volts in free air and greater than 10,000 volts when encapsulated. They consist of a gallium arsenide infrared LED coupled with either a silicon phototransistor or photodarlington in a molded plastic package. Standard pin spacing of 0.300 x 0.100 inch is compatible with that of dual in-line sockets.

Current transfer ratios range from 20% to 100% for the phototransistor versions (OPI 7002/OPI 7010), and from 200% to 400% for the photodarlington models (OPI 7320/OPI 7340).

New OPI 7000 series isolators are interchangeable with similar products as follows:

TRW Optron	GE
OPI 7002	H15A2
OPI 7010	H15A1
OPI 7320	H15B2
OPI 7340	H15B1

In addition, TRW Optron's complete line of isolators includes standard devices in high-rel metal cans and low cost DIP and other plastic configurations for most applications.

Detailed technical information on optically coupled isolators and other TRW Optron optoelectronic products . . . chips, discrete components, reflective transducers, and interrupter assemblies . . . is available from your nearest TRW Optron sales representative or the factory direct.

TRW OPTRON
A DIVISION OF TRW INC.
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Carrollton, Texas 75006, U.S.A.
TWX-910-860-5958
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CIRCLE 9

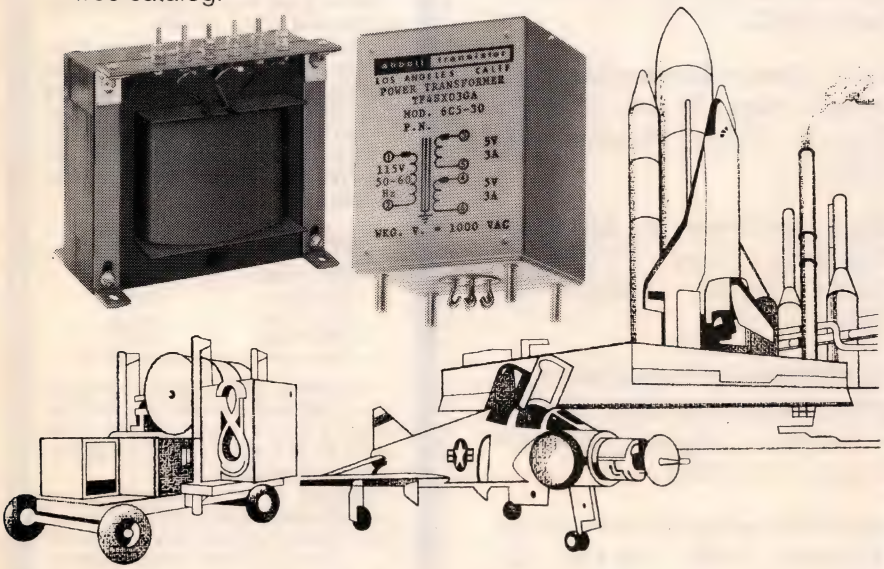
Let Us Help You design the Power Transformer You Need!

Let's discuss electrical and mechanical requirements for your new power transformer design. Let's talk about vibration, shock, temperature, humidity . . . specifically in terms of *your* design needs.

Would an encapsulated unit be most efficient, or should it be hermetically sealed? What are your options for mounting hardware? Do you need thru-holes or threaded inserts for versatile mounting?

Our design engineers have many years experience helping to create custom designs to meet MIL and other applicable specs. Every transformer we build is subject to rigid production and quality control procedures to MIL-I-45208. This insures compliance to the electrical and mechanical specifications. Add to this our design philosophy and quality materials, and you get optimum reliability.

Let us act as your consulting service. Many of the nation's largest industrial and military manufacturers already consider ABBOTT as the prime source for standard as well as specialty transformers. Call now or write for our free catalog.



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CIRCLE 10

Letters

(continued from page 13)

plot 44 actually operates: "Using any one of the 96 ASCII character codes, the device transforms digital information into alphanumerics or graphics on a 44 × 22 character X-Y plot."

The correct operation is as follows: "The Microplot 44 accepts analytical and computational data in digital form and can print, plot grids and scales, and annotate plots."

Sheldon D. Spencer, Chairman
Spencer, Bennett, Nowak, Inc.
70 Harborside Dr.
Providence, RI 02905

When the prices go down, down, down

We were pleased with ELECTRONIC DESIGN'S coverage of Silicon General's new SM1400, a 10-A, 150-W regulator. (May 10, 1980, p. 272), but have a modest dilemma regarding the quoted price of $60 (in hundreds). That was indeed the arbitrary price we retained for occasional quoting during the product's development and was valid at the time ELECTRONIC DESIGN gathered information for the article. Subsequently, however, we developed considerably more manufacturing experience and have just made a significant revision in the earlier price structure, viz., from $60 to $17.25 (in hundreds).

Charles McCarthy
Vice President
Marketing and Sales
Silicon General Inc.
11651 Monarch St.
Garden Grove, CA 92641

NO.13

NATIONAL ANTHEM

SEMICONDUCTOR NEWS FROM THE PRACTICAL WIZARDS OF SILICON VALLEY.

Microcontrollers and freedom of choice.

THE COPS™ FAMILY IS THE PRACTICAL APPROACH TO MICROCONTROLLER APPLICATIONS.

High quality RAMs now available in all speed ranges

Linear bestsellers for 1980

High-speed buffer amps drive heavy loads

National commitment to ROM production

State-of-the-art op amps for high-speed designs

Important news from the National Archives

Data Acquisition   Logic   Transistors   Hybrids   Linear   Interface   Bubble Memory
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Memory Boards · Microprocessors   Development Systems   Microcomputers   Modules

NATIONAL ANTHEM

National emerges as the logical choice for memories.

By substantially increasing their production capacity, National is meeting the demand for high-quality 16K dynamic RAMs.

National Semiconductor has made a major commitment to the high-density RAM marketplace by significantly stepping up their production capacity.

As a result, their competitively priced MM5290 16K dynamic RAMs are available in production quantities right now through your National distributor or sales representative. (Call for pricing information.)

And with their exclusive combination of design and manufacturing procedures, the MM5290s are setting new industry standards for quality and reliability.

For example, the popular MM5290 Family is designed so that soft errors induced by stray alpha particles are virtually eliminated.

This, combined with National's extensive component test procedures, assure unsurpassed operational integrity and dependability in every high-speed, high-density RAM application.

The first and only MST.™ In addition to National's use of conventional final testing and QA component level processing, many customers request National's unique MST (Memory Systems Test) program.* MST eliminates or greatly reduces the customer's own requirements for internal testing. So their incoming test, board test and system rework costs are substantially reduced.

For more detailed information about MST and the MM5290 Family – plus a Reliability News Brief on alpha particle test results – be sure to check the National Archives coupon.

Quality RAMs from a quality source. National has, of course, been known as a quality production house for a long time.

And now they've made an unprecedented full-force commitment to the RAM marketplace. A commitment based on the industry's most advanced design, fabrication and testing techniques.

And thanks to their unmatched production capacity, this kind of quality in every kind of RAM is now even easier to get than you ever thought possible.

From start to finish, the Practical Wizards from National are doing more to meet all your memory needs than anyone has ever done before.

---

*Patent pending.

MST is a trademark of National Semiconductor Corporation.

COPS™ microcontrollers. Practicality runs in the family.

National's small, low-power COPS microcontrollers offer superior program efficiency and versatility in over 21 architecturally compatible varieties.

As every design engineer knows, there is always more than one way to do a job and do it well. Especially when there are not a lot of design limitations imposed by key components.

This is exactly what the Practical Wizards at National had in mind when they developed their COPS Family of microcontrollers. The COPS Family literally surrounds the engineer with over 21 different yet architecturally compatible microcontrollers to choose from.

A multi-dimensional array of products. Each family member shares a common CPU architecture and instruction set that are significantly more efficient than any other microcontroller available.

In order to make the most of this efficiency, COPS presents these features in a multi-dimensional array of over 21 practical, low-cost components (all of which may be programmed using National's COP400-PDS development system).

So now the engineer can pick and choose from a wide variety of key specs: CPU size, fabrication technology (CMOS, low-power NMOS, high-speed NMOS), the temperature range, the voltage range, the speed, the I/O options and the package size and type.

In short, the COPS Family offers a truly broad range of compatible microcontrollers and dedicated peripherals to closely match the requirements of each design.

This is exactly why the COPS Family is the much more practical and cost-efficient approach to all microcontroller and many μP applications.

Available now in production quantities. Thanks to National's massive production capacity all COPS Family microcontrollers are currently available in large quantities.

And as always, all orders for these low-cost, low-power COPS components are accompanied by National's unequaled documentation, plus FAE and factory applications support.

COPS is a trademark of National Semiconductor Corporation.

Linear Data Book tops National bestseller list.

National announces the new 1980 Linear, Data Acquisition, Voltage Regulator and Audio data books. And until Labor Day, they're all yours for $20* complete.

National, the long-time Linear leader, is known for their clear, concise and comprehensive data books. And the 1980 books are certainly no exception to the rule.

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And until Labor Day, you can add this perennial bestseller to your reference library for only $6.00 ($3.00 off the regular price).

Linear and Data Acquisition – a perfect match. If you're into data acquisition and control systems, National has you covered.

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And between now and Labor Day, National will sell you four of their bestselling 1980 books – Linear, Data Acquisition, Voltage Regulator and Audio – for only $20.00 complete. That's a full $8.00 off the regular selling price.

The 1980 Voltage Regulator Handbook covers power supply and regulator design all the way from the transformer to the heat sinks.

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To get your copies, simply fill out and send in this issue's National Archives coupon. Please indicate the quantities desired and include a check or money order for the appropriate amount.

All orders postmarked by Labor Day – September 1 – will qualify for this special offer, so don't delay.

*Prices shown are U.S. prices only.

1980 LINEAR DATABOOK
1980 DATA ACQUISITION HANDBOOK
1980 VOLTAGE REGULATOR HANDBOOK
1980 AUDIO HANDBOOK
National Semiconductor

The LH0024 and LH0032 op amps— the best in the business.

State-of-the-art techniques go into the industry's only single-package versions of these popular high-speed op amps.

Ever since National began making their LH0024 and LH0032 high-speed op amps, they've been the industry favorites. And for good reason.

For starters, they use state-of-the-art thin and thick film technology in making the only single package versions of these op amps currently available.

Both the LH0024 and the FET-input LH0032 offer a very high slew rate (500V/μsec), a wide bandwidth (70MHz), low input offset voltage (2mV), a null offset with a single pot, and both are available in military and commercial temperature versions.

In addition, both are available in versions to meet military standard 883 level B specs. So not only are these op amps put through special testing and REL processing, they are also subject to National's own stringent REL and QA standards and procedures.

These low-priced op amps are ideally suited for a variety of high-speed applications. Active filters, oscillators, comparators, summing amplifiers, sample and hold circuits, D/As and A/Ds, and many others.

Check the National Archives coupon for LH0024 and LH0032 data sheets and assorted application ideas and information. All free from the Practical Wizards of Silicon Valley.

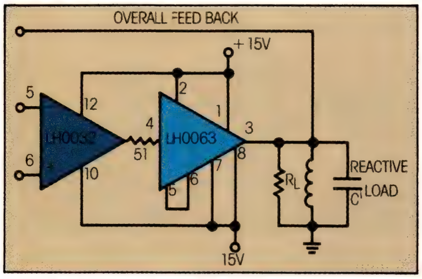
6000V/μsec buffer amps drive heavy loads.

The LH0002, LH0033, and LH0063 have been the industry's most popular buffer amps for some time now, simply because their high-speed special function circuits drive the kind of high-capacitive lines that can choke typical buffers. And to make a great thing even better, National has just assembled two brand new documents full of innovative applications and other detailed information about their buffers. (Check out the Special Functions Databook and Applications Note 227 on the coupon below.)

The LH0002/33/63 buffer amps will drive up to ±500 mA into a 50 Ω line at slew rates from 200 to 6000V/μsec.

National's laser-trimmed buffer amps solve design problems with high-capacitive coax line drivers, video amps, high impedance input buffers for fast A/Ds and comparators, and diddle yoke drivers.

The Practical Wizards of the Special Functions Group also offer LH0002/33/63s that meet mil. std. 883 level B specifications. The multiple testing and REL processing performed on these devices complement the inherent quality of every buffer amp that National produces.



LH0032 and LH0063 used as an isolation buffer.

National stays ahead of ROM demand.

When it comes to buying ROMs, a peculiar situation all too frequently arises.

It seems that most major suppliers of ROMs seldom stay major for very long. One month they'll produce ROMs like there's no tomorrow, but the next month they'll leave you high and dry.

Whether it's due to a new product push or whatever else, it always seems to be their ROM production that suffers. And that means you suffer, too.

All because they're just not serious about the ROM business.

National is committed to memory. National Semiconductor, on the other hand, is fully committed to keeping up with the ROM demand. Today, tomorrow, and every day thereafter.

Their large-scale ROM dedicated production facilities offer both consistent supply and consistent lead times.

That's why National is establishing a reputation as the industry's most dependable supplier of ROM components.

And not only can you count on a supplier that doesn't shift with the tides, you can also count on a fine-tuned support organization to back you up. One that's ready and able to answer all of your questions all of the time.

For further information regarding National's supply of ROMs, send in the coupon below. For samples, contact your local sales representative or distributor.

If you're looking for a consistent, dependable ROM supply at very competitive prices, come to National. We're committed to memory.

What's new from the National Archives?

006 ☐ Special Functions Data Book ($6.00)
009 ☐ ROM MM52116 Data Sheet
010 ☐ ROM MM52132 Data Sheet
011 ☐ ROM MM52164 Data Sheet
015 ☐ MST Program Brochure
021 ☐ LH0002/33/63 Information and AN227
028 ☐ Additional COPS Family Information
035 ☐ Additional Series/80 Information
036 ☐ Optoelectronics Handbook ($3.00)
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038 ☐ MM5290 Data Sheet and Additional Information
042 ☐ LH0024, LH0032 Information and App Note
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044 ☐ 1980 Linear Data Book only ($6.00)* qty___
045 ☐ 1980 Data Book Package (4 books; $20.00)* qty___
*Prices effective until September 1, 1980

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The Practical Wizards of Silicon Valley

NA 13

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Is the WG80 a versatile connector?

We lost count at 2700 variations!

For openers, the WG80 series connector compresses 80 contacts into a 3.5″ long molded body (including mounting shoulders) by using three rows on .100″ centers, staggered .050″.

Next, it offers any combination of contacts, terminations, and polarizations for PC board to chassis, PC board to cable, or chassis to cable applications.

What's more, it's rugged and reliable. Made with highest-quality materials — glass-filled diallyl phthalate body and gold-plated contacts — the WG80 conforms to MIL-C-55302, and probably exceeds your most demanding requirements. After all, it's from AirBorn.

AirBorn, Inc.

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Addison, Texas 75001
(214) 233-2000

CIRCLE 11

The new way to ease the pain of microprocessor interfacing.

CRYDOM BUFFERED I/O MODULES!

These are the new high performance interface switches for electrically clean, photo-isolated (4000V RMS min.), noise-free interfacing between CMOS or NMOS microprocessors or TTL and any other logic-based controllers and the associated devices in your new system.

The Crydom Touch.
Physically and electrically equivalent and pin compatible with older versions offered by other manufacturers, the new Crydom Series 6 Input/Output modules offer several advantages the others can't provide.

Higher Output Current.
All Crydom output modules can control loads up to 3.5 Amps @ 45°C as compared to 3 Amps (or less) for the others. A larger heat spreader, thinner case walls and optimum thermal conductivity encapsulating epoxy enable ours to dissipate heat faster and run cooler, permitting greater current handling capability.

Buffering: The big design advantage.
The others' output modules require special add-on, external buffering circuits to reduce the input drive requirements to a level suitable for microprocessor MOS devices. The Crydom Touch has eliminated this often painful exercise. Buffering is built into selected output modules to reduce your design time and production costs. And you'll end up with an uncluttered control assembly.

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CIRCLE 12

LateNews

MicroEngine Pascal computer gets new support

The powerful 16-bit MicroEngine Pascal computer system offered by Western Digital's subsidiary MicroEngine Company (Newport Beach, CA), acquires even more versatility from two new developments: an interface for the combination hard and floppy-disk storage of the Data Warehouse system from Remex (Irvine, CA) and a more modularized multiple-board version of the MicroEngine (now in design).

The Data Warehouse subsystem interface expands the memory with 20 Mbytes (unformatted) of fixed disk drive and two 1-Mbyte floppy disk drives for removable storage. Data transfers take place at 960 kbytes/s for the fixed disk and 62.5 kbytes/s for the floppy disks. The entire subsystem, which is compatible with the UCSD Pascal operating system, includes the multiple-drive package, the controller to interface the drives to the WD/90 or WD/900 Pascal MicroEngines, and the required cables.

The ME 1600 computer system—to be unveiled in the late third quarter—is a multipurpose 16-bit system configured with plug-in boards for simple system expansion and set up. Initially, four boards will be available, along with a card cage/power supply and a disk subsystem. The four boards will consist of the MicroEngine CPU, a 128-kbyte memory card, a disk-controller card and a multiple I/O card (two parallel ports and four serial ports).

Future support cards for the system will include a data encryption subsystem, a real time clock card, analog I/O boards, a Data Warehouse interface and a bus-interface card with a breadboard area. The system will also use a proprietary bus structure that will handle up to 16 Mbytes of memory. Memory management schemes will permit dynamic reallocation of the memory.

Raster-scan graphics goes beyond stroke-refresh

A raster-scan graphics system that offers software compatibility with existing stroke-refresh systems plus more capability is coming from Sanders Associates, Inc. (Nashua, NH). The Graphic 8 is not only software-compatible with the company's existing Graphic 7 stroke-refresh graphics systems, but also features more screen area, fill capability, color discrimination and screen use.

A digital vector generator uses bit-slice microprocessors for dynamic updates, while dual memories allow full screen updates. What's more, total screen-addressing capability extends to an interlaced 1024 × 1024 (using 16-bit addresses).

Up to eight fully interactive terminals can be linked to a controller CPU. In addition, color discrimination is for 256 colors, while 256 levels of the grey scale are available for black and white uses. A parallel interface is rated for a half-million 16-bit words per second from the CPU to the display screen and, as with the Graphic 7, three-dimensional modules are available.

GRnet will handle ATE data-comm

GenRad Corp. (Concord, MA) has developed an Automatic Test Equipment communications network. Tailored for production tests, it accommodates up to 64 systems on a single line. The 2291 GenRad Network (GRnet) links a GenRad 2290 multiuser programming station to any GenRad in-circuit test system, functional test system or programming station. System components are network interface modules (Z80-based microcomputers that interface to the host system via DMA; connecting cables for daisy-chaining a network up to 2,000-ft long; and system software.

At a simple keystroke from the test system's high-level monitors, GRnet transfers data at up to 655,000 bits/s. Throughput is 40,000 bits/s, even when up to four transfers are executed simultaneously. GRnet employs Synchronous Data Link Control protocol.

The 2990 multiuser programming station, with up to 500 Mbytes of disk storage, automatically sends requested test files directly to the production test systems. Programming or editing functions from production systems can also be offloaded via GRnet, using remote programming terminals.

Chip-inserter spots 250 chips in 7s

Several manufacturers have been quietly displaying chip-insertion equipment in the back rooms at trade-shows, but the very first company with an available product is the Components Division of TDK Corp of America (Indianapolis, IN). Manufactured in Japan, the AVI-Mount CM-3 handles a variety of chip components—capacitors, resistors, transistors, diodes and inductors—in at least three standard EIA sizes (93.2 × 1.6 × 0.6 mm, 4.8 × 2.4 × 0.6 mm, or 4.8 × 2.4 × 1.1 mm). Up to 250 chips from plastic chutes can be placed in each 7-s cycle on 2.5-mm centers.

JFET op amp cuts noise, stretches bandwidth

Low noise and wide bandwidth are the key attributes of a junction-FET op amp that will soon be announced by Harris Semiconductor (Melbourne, FL). The HA-5160 has a gain-bandwidth product on the order of 80 MHz, a voltage gain of 60,000 and noise on the order of 15 $\mathrm{nV}/\sqrt{\mathrm{Hz}}$. Slew rate is typically 130 V/μs, and settling time is within 500 ns to within 0.1% of a ±10-V step. The Harris JFET unit follows closely on the heels of the company's HA-5130 bipolar op amp, which has 10^6 voltage gain, 25-μV input offset voltage, 3-nA input bias current and 10-$\mathrm{nV}/\sqrt{\mathrm{Hz}}$ noise.

Single-chip CMOS ADC consumes less than 1 mW

A 3½-digit single-chip CMOS a/d converter will pack input buffer amps, an integrator, a comparator, a reference, a clock and seven-segment decoders, yet consumes less than 1 mW from a single 9-V battery. As a result, the ICL7126, soon to be announced by Intersil (Cupertino, CA), will provide at least 8000 hours of battery life in hand-held digital multimeters. It also will return to zero with less than 10 μV input offset, and will drift less than 1 μV/°C.

In-circuit tester handles dense LSI

A new system from Plantronics/Zehntel (Walnut Creek, CA) performs in-circuit tests of LSI components, like dense memory chips, microprocessors and controllers—a feat previously difficult for in-circuit testers. The Data Director permits any programmer familiar with the mnemonics of the LSI device to write a test program for the device, eliminating the need for skilled test programmers.

ANSI bus standard coming

Prior to final voting in September, ANSI standards specification X3T9.0 "Small Computer to Peripheral Bus Interface" is coming under public review. It defines a general-purpose, high performance interface for tying peripherals to a computer system.

According to Jim Pisarsik, an ANSI committee member and Senior Manager of peripheral development at Perkin Elmer, the interface calls for a maximum cable length of 30 meters. Up to 16 devices (including the computer) could be attached to this cable. The standard would allow both 8-bit wide and 16-bit wide parallel communication at 1 and 2 Mbyte/s.

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CIRCLE 13

Vrrroom.

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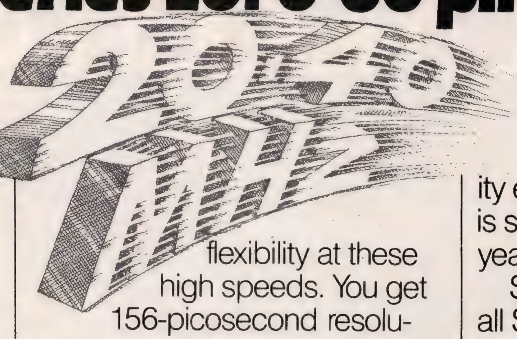

The faster your LSI devices, the more you need our latest breakthrough. Because our new Sentry® Series 20 is one of the fastest LSI test systems around. It can test a full 60 pins of microprocessor, memory and peripheral chips at an uncompromised 20 MHz. Or 30 pins at 40 MHz.

The Series 20 system uses 10K and 100K ECL throughout all formatters, timing paths, pipeline and local memory sections. You get faster throughput and faster data formatting.

You'll test MOS and bipolar memories, microprocessors and peripheral chips that run above 10 MHz. Static RAMs, bit slice microprocessors and microprogrammable controllers that run above 20 MHz. And you'll be able to characterize these high speed devices as they're designed. In fact, Series 20 is the only commercially available tester that can provide full 60-pin I/O operation at 20 MHz.

Series 20 also features an enhanced timing system that gives you increased accuracy and flexibility at these high speeds. You get 156-picosecond resolution to place edges accurately when testing AC parameters. And 16 timing generators so you can program up to 32 edges independently. You can even change each edge between 16 different values on the fly.

Series 20 gives you expanded memory capacity. Up to 196K 24-bit words give you the program capacity needed to test future high-speed devices. And our new fast, fixed head disk gives you a two-to-one speed advantage in access time while expanding your program capacity even further. Your investment is solid today and protected for years to come.

Series 20 is compatible with all Sentry software. So you don't have to wait for programs to be developed. You can start right up, using existing Sentry programs without incurring heavy retraining and programming costs.

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CIRCLE 14

We've got a name for KEMET® ceramic capacitors Customers.

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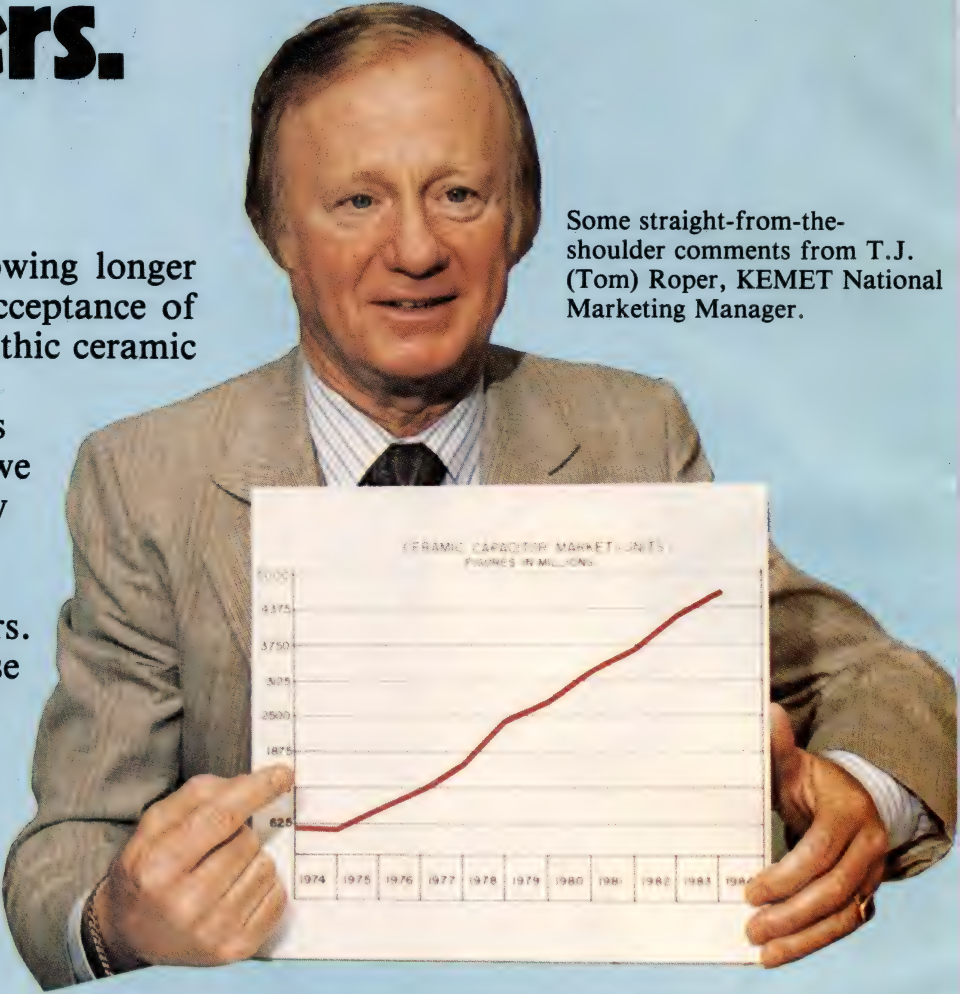
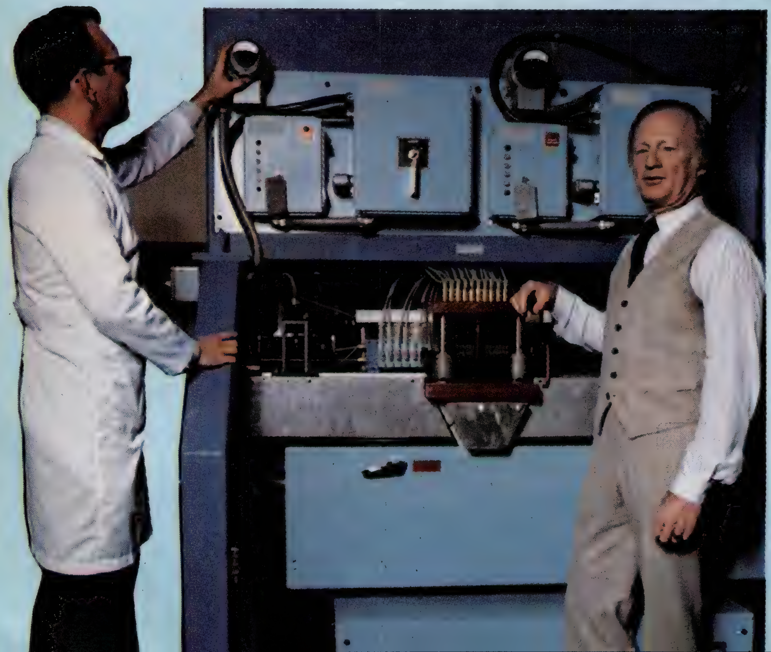
This growth has provided great things for our customers. It has permitted us to increase our production facilities and quality assurance programs immensely. So KEMET customers can continue to take our quality and availability for granted.



Some straight-from-the-shoulder comments from T.J. (Tom) Roper, KEMET National Marketing Manager.

The only way we can get the machines we need is to build 'em.



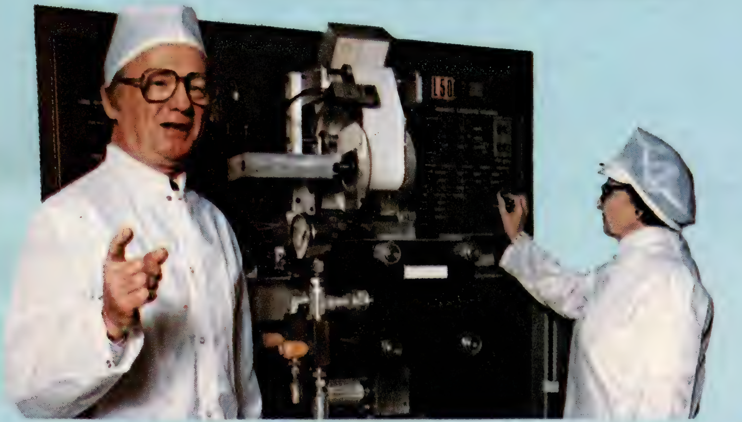
No other manufacturer takes greater care in the manufacture of monolithic ceramic capacitors than KEMET. Because no other manufacturer has more extensive Research and Development facilities and unique manufacturing methods than Union Carbide. More than 70 staff equipment designers, engineers, chemists, draftsmen, technicians and machinists work full-time to keep KEMET out front. With computer controlled testers, ceramic sheet casters, laminators and dozens of other ingenious innovations.

Quality is built in, not inspected in.

Every step of production ends with an in-process quality control inspection. You never see the products that don't make the grade. If they fail our rigid tests, they fail. Period. Our testing procedures put greater stress upon the capacitors than they will probably ever see in actual circuit application.

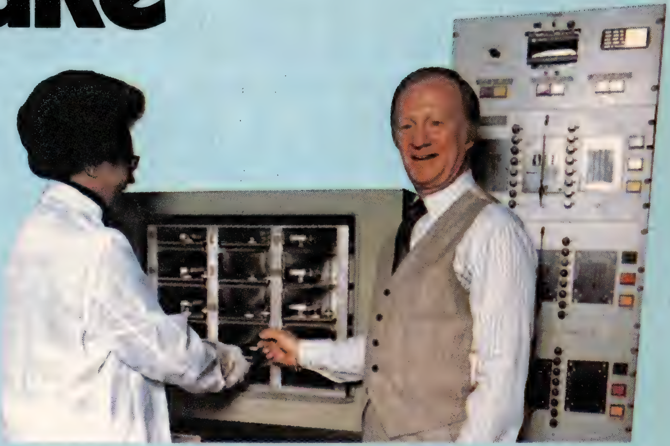
people who take for granted.

At KEMET, we take reliability very seriously. This multi-million dollar, Federal Class 100 clean room is where KEMET High-Reliability ceramic capacitors are born. This "plant within a plant" is totally isolated from other production areas, is operated by its own support group and is completely equipped with its own technically advanced processes and equipment. This specialized facility is your assurance that KEMET High-Reliability ceramic capacitors are specifically built to meet or exceed **MILITARY requirements.**



With KEMET High-Reliability ceramic capacitors, customers get a "life" history.

KEMET customers get only the best when they order High-Reliability ceramic chips or molded radial or axial leaded capacitors – we back these products with performance data and destructive physical analysis (DPA) results. Each capacitor undergoes in-process testing and ultrasonic scanning to detect voids and delaminations. The proof of quality is demonstrated in the DPA lab, where samples are literally torn apart.



Here, the good parts get burned-in; the rejects just get burned.

Every KEMET ceramic capacitor undergoes in-process testing at each production operation, plus stringent final quality control inspection. But that's not enough for us. All Military grade products are subjected to 100-hour burn-in at 125°C. Only the strong survive and earn the KEMET brand name – and get shipped to our customers.

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We've learned a lot about monolithic ceramic capacitor technology since 1968. And it's reflected in the high quality of all KEMET ceramic products. Molded radial and axial leaded. Blue Max, Mighty Max and space-saving "Solder Guard" chips. In ultra-stable NPO and COG; stable BX, BR and X7R; and general-purpose Z5U dielectrics. Operating temperature from -55°C to 125°C. Total capacitance range from 1 pF through 6.8 uF in 50, 100 and 200 volt ratings. Also, there's EPIC, Union Carbide's computerized on-line Electronic Product Inventory Control system. Using EPIC, we can determine KEMET factory stock levels, place orders directly and provide delivery within 24 hours. Our customers can take KEMET monolithic ceramic capacitors for granted. Because we don't.

For more data, write to Electronics Division, Union Carbide Corporation, Box 5928, Greenville SC 29606. Phone: (803) 963-6300; TWX: 810-287-2536; Telex: 57-0496. Or see your local KEMET representative.

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CIRCLE 15

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For more information on any or all of these high-speed hybrids, circle the appropriate reader service number(s) or call (919) 292-6427.

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Unlike most universal µP development systems, the ECL-3211 is software-driven, making it easy to convert from one chip to another—even to a chip just introduced.

Universal development system emulates to 30 MHz

A universal microprocessor development system built around readily available PDP-11 computers, peripherals and operating systems reportedly will handle any 4 to 32-bit µP at speeds up to 30 MHz. Developed by Emulogic Corp. (Westwood, MA), which adds its own high-speed emulation and control logic along with applications software, the ECL-3211 is software-driven, unlike most other development systems. As a result, all it takes to convert from one chip to another is software for the new chip and an adapter card.

In addition, the same emulator hardware is used to emulate any µP chip. And since the design job is a software, not a hardware task, Emulogic says it can provide emulation support for new chips usually in less than 30 days.

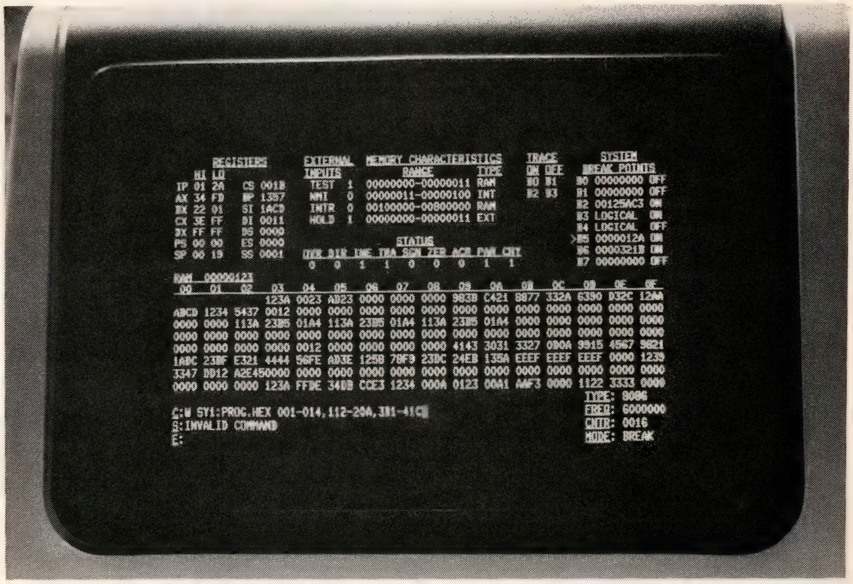
Providing a full-screen display for each µP emulated (see photo), the ECL-3211 presents the operator with a complete status update of every item in the target. This is done automatically without calling anything from the keyboard. Split-screen scrolling lets the operator easily scan through RAM, ROM or a trace buffer.

Data stored in the 512 × 64-bit trace buffer are determined by the adapter card for each µP chip. Trace contents can be displayed in the scroll area in either hexadecimal form or in disassembled mnemonics.

Eight breakpoints are provided, each of which can be used with any chip up to 32 bits and may be defined as a logical function, in which a specified action is taken if the logical state of the system equals the state described by logical arguments. Each bit in an argument may be described as a 1, 0, or X (don't care).

Incidentally, the eight breakpoints, in combination with the 512 × 64-bit trace buffer, event counters, elapsed-time timer, and full-screen display provide a built-in 64-channel, real-time logic analyzer. BNC connectors are also provided on the emulator pod for connecting standard probes to the eight external lines. Two trigger outputs are provided via the BNC connectors to trigger or synchronize external instruments such as oscilloscopes or stand-alone logic analyzers.

Relocatable macroassemblers are provided for each µP chip supported. A consistent command structure is used throughout and all processors employ standard PDP-11 pseudo-ops, eliminating unnecessary confusion and "relearning" when



```
      REGISTERS        EXTERNAL  MEMORY CHARACTERISTICS  TRACE       SYSTEM
      HI LO            INPUTS         RANGE        TYPE  ON OFF    BREAK POINTS
   IP 01 2A   CS 001B  TEST  1  00000000-00000011 RAM    B0 B1   B0 00000000 OFF
   AX 34 FD   BP 1357  NMI   0  00000011-00000100 INT    B2 B3   B1 00000000 OFF
   BX 22 01   SI 1ACD  INTR  0  00100000-00800000 RAM            B2 00125AC3 ON
   CX 3E FF   DI 0011  HOLD  1  00000000-00000011 EXT            B3 LOGICAL  ON
   DX FF FF   DS 0000                                            B4 LOGICAL  OFF
   PS 00 00   ES 0000               STATUS                      >B5 0000012A ON
   SP 00 19   SS 0001  OVR DIR INE TRA SGN ZER ACR PAR CRY       B6 0000321B ON
                        0   0   1   1   0   0   0   1   1        B7 00000000 OFF
RAM  00000123
 00   01   02   03   04   05   06   07   08   09   0A   0B   0C   0D   0E   0F
               123A 0023 AB23 0000 0000 0000 9B3B C421 B877 332A 6390 D32C 12AA
ABCD 1234 5437 0012 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 113A 23B5 01A4 113A 23B5 01A4 113A 23B5 01A4 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0012 0000 0000 0000 0000 4143 3031 3327 0B0A 9915 4567 9821
1ABC 23BF E321 4444 56FE AD3E 125B 78F9 23DC 24EB 135A EEEF EEEF EEEF 0000 1239
3347 BD12 A2E450000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 123A FFDE 340B CCE3 1234 000A 0123 00A1 AAF3 0000 1122 3333 0000
                                                                   TYPE: 8086
C:W SY1:PROG.HEX 001-014,112-20A,3B1-41C                           FREQ: 6000000
S:INVALID COMMAND                                                  CNTR: 0016
E:                                                                 MODE: BREAK
```

Emulogic display for 8086 emulation lists breakpoints, shows the status of such sections as registers and external inputs, and can scroll RAM contents without disturbing balance of display.

working with a new chip family. The mnemonics used with each assembler are identical to those of the chip manufacturer.

The system includes a license for either RT-11 or RSX-11M operating systems. RT-11 is DEC's basic system and RSX-11M is available as an option on some models. RT-11 is a real-time operating system designed for interactive program development and on-line applications for the PDP-11. It supports both single-job and foreground/background modes of processing and such high-level language compilers as Basic, Fortran, Pascal, Dibol, etc. It also provides indirect command-file execution so that sets of commands can be executed via single keystrokes or called automatically on system startup.

RSX-11M is one of DEC's most powerful operating systems for the PDP-11—the result of more than 300 man-years of software development effort. Among other things, it can be used simultaneously by up to 64 users, and it does multitasking.

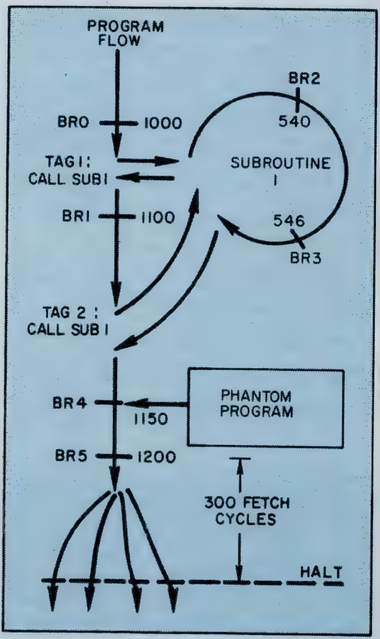
A general-purpose text editor using the function keypad and the full spectrum of video features of the VT-100/VT-103 CRT terminal is also supplied. The editor permits the user to execute most functions with only one or two keystrokes and, when editing a main file, to copy material in from one file while writing out to an auxiliary file. It also permits the user to edit files through a full-screen, bidirectional smooth-scrolled window into the stored file.

The linker converts relocatable object modules into a run-time format, converts relative addresses to absolute addresses, and links global references among object modules. In addition, the linker permits library functions and user-written subroutines to be assembled separately and linked for execution as required.

Stephen E. Scrupski

Using the breakpoints

The Emulogic ECL-3211 allows flexible use of breakpoints during program debugging. For example, BR2 in subroutine 1 allows the operator to trace when the subroutine is called from location TAG1 only, and not when called from TAG2. The phantom program feature, invoked at BR4, permits the operator to inject a program anywhere in the target program without using any memory space in the target. This can be useful in final debugging stages, after the PROM is burned or when RAM is full. The table details the functions performed at each breakpoint.



Entry format	Function performed
BRO S1/PC=1000	Set logical switch 1 when PC equals 1000.
BR1 R1/PC=1100	Reset switch 1 when PC equals 1100.
BR2 ST/S1=1, PC=540	Turn trace on when PC equals 540 if switch 1 is set. (Turn trace on if subroutine is called from location TAG1)
BR3 RT/PC=566	Turn trace off when PC equals 566.
BR4 PH/PC=1150	Inject "phantom program" when PC=1150.
BR5 H,ST/PC=1200+300	Turn trace on when PC equals 1200; halt when PC = 1200 + 300.

16-bit μCs seek new types of support

The mounting programmer shortage and the popularity of 16-bit μCs are changing industry attitudes toward development systems:

- Faster compilers and more powerful debugging tools are needed to increase programmer productivity.
- Complex μC software requires powerful block-structured languages for fast development.
- Software-module libraries are creating a demand for more mass-storage.
- The megabyte addressing ranges of 16-bit chips call for huge memory spaces.

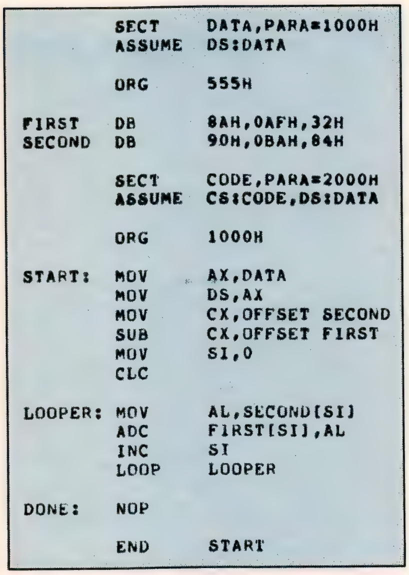
Since small dedicated development systems can not cope with these needs, a switch to mini or mainframe-based cross-development for μCs is gathering steam. The evolution at Intel exemplifies the trend: After adding the hard-disk Model 245 to its line last year, the μC pioneer now offers a "mainframe link" that provides a multiuser, multiprocessor environment. Later this year, the Series 3 system will provide another multiuser alternative, enhanced by new high-level languages like Pascal-86 and Fortran-86.

More Pascal support

Motorola labels its 6800-based EXORmacs "the industry's most powerful 8/16/32-bit multistation development system." It supports Pascal and will eventually support Fortran and MPL. With a 32-bit address bus, the system has an addressing capability of 4-billion bytes that should satisfy the most ambitious planners. Four μCs in the "mainframe" and one more in each work station give the EXORmacs nearly as much processing power as a mini. Motorola points out that the software designers can use Cross Pascal for IBM-370 and PDP-11 computers and can then downline load the object code into a 6800 Design Module or EXORmacs.

As systems get more complex, designers often prefer to try their software on several μCs. Universal development systems address this preference. Hewlett-Packard's 64000 attacks productivity in μC development from two directions: large-system storage (on either a 12-Mbyte or 125-Mbyte hard disk) and an effective man/machine interface. HP's proprietary 16-bit processor can change a 2000-line program in less than 3 min., including 75 s for editing and 42 s for reassembly and linking. Since HP considers "free disk space" to be the major prerequisite for programmer productivity, the 64000 can expand to 980 Mbytes.

In any comparison of chip support, the universal development system from Boston Systems Office is hard to beat. It supports 25 μP families (including bit-slices) marketed by 23 manufacturers. In the fall of 1980, Zilog's Z8000 and Motorola's 68000 will join the available 16-bitters. BSO's systems are based on LSI-11/2s for one to six users and on PDP-11s for systems that accommodate up to 75 users.



```
        SECT    DATA,PARA=1000H
        ASSUME  DS:DATA

        ORG     555H

FIRST   DB      8AH,0AFH,32H
SECOND  DB      90H,0BAH,84H

        SECT    CODE,PARA=2000H
        ASSUME  CS:CODE,DS:DATA

        ORG     1000H

START:  MOV     AX,DATA
        MOV     DS,AX
        MOV     CX,OFFSET SECOND
        SUB     CX,OFFSET FIRST
        MOV     SI,0
        CLC

LOOPER: MOV     AL,SECOND[SI]
        ADC     FIRST[SI],AL
        INC     SI
        LOOP    LOOPER

DONE:   NOP

        END     START
```

Boston Systems Office benchmarks use this 8086 program.

BSO has just released data on some benchmarks, using a PDP-11/70 running under IAS, with 11 users logged on. Three programs were tested: SPEED-00, consisting of 5000 NOPs without labels or comments: SPEED-85, an 8085 program to calculate primes, appended to itself for a total length of 1000 lines; and SPEED-86 in an 8086 program (see Fig.), again repeated to total 1000 lines. The results speak for themselves:

Program	Assembly time	Lines/ min.
SPEED-00	19.0 s	16,000
SPEED-85	6.8 s	8,800
SPEED-86	7.5 s	8,200

Since BSO's system also provides real-time debugging via Tektronix 8001 or any other μP hardware-development tool, it makes a strong case for mini-based development systems.

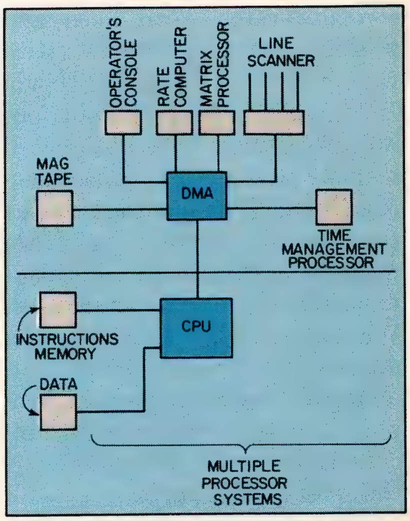
Max Schindler

Multi μPs untangle comm switching, but protocol snag remains

In their hardware and software, communications and computing equipment increasingly intertwine: μPs and packet-switches containing μPs are facilitating communications throughput, and the protocols for data processing are becoming critical concerns for telecomm standard-makers. This year's International Conference on Communications (June 8 to 12, Seattle, WA) addressed developing comm/computer connections.

The architectures of new 16-bit μPs favor communications systems with improved interrupt and bit-handling capabilities, virtual storage and DMA, according to Subhash Bal of National Semiconductor (Santa Clara, CA). Bal proposes designs for PABXs and Class-5 central-office digital switches based on his company's NS16000 μP.

In the PABX, the usual line card becomes a μP-based subscriber port that can insert (and trip) ringing signals, generate dial tones, switch between tone



μP-based CPUs communicate with dedicated μP-based processors in the Class-5 central-office switch proposed by National Semiconductor.

and pulse dialing, manage call priorities, count dial pulses, assign time slots (digital PABX) and determine call locations (inside or outside).

Telephone switching systems usually accommodate very few interrupts, says Bal. However, PABX designs that lean heavily on interrupts could deliver higher throughput, especially for machines that service many ports. Preprocessing, by distributing CPU functions onto μP-based line cards, could justify switch architectures based on CPU interrupts rather than the usual polling schemes. In such large-scale equipment, the processing speed of the line-card μPs is a secondary consideration. What is important is the CPU's interrupt-response and recovery speed.

In addition, the CPU should offer high throughput and fast bit manipulation to route calls through the PABX matrix and process dialed numbers. Not surprisingly, Bal recommends 16-bit μPs, with vectored-interrupt capability, like the NS16000. Additional μPs could handle line-card, matrix-processing and call-monitoring functions.

In Bal's version of a Class-5 digital switch, separate μPs that compute rates, scan lines and perform other functions interface with the main CPU via DMA. Each processor transfers its information to a designated mailbox in the CPU data memory. The CPU sequentially cycles through its various program modules and processes the data from the appropriate mailboxes. When required, the CPU passes its processing results to the satellite μPs, such as the rate computer and time-management processor; it treats the μPs as if they were DMA ports.

Bal notes that the data memory in his Class-5 switch can be huge; the program memory is sizable too. Memory size can vary widely depending on optional features and number of lines served. Hence, virtual-memory capability for managing flexible storage is an important feature for CPU candidate processors.

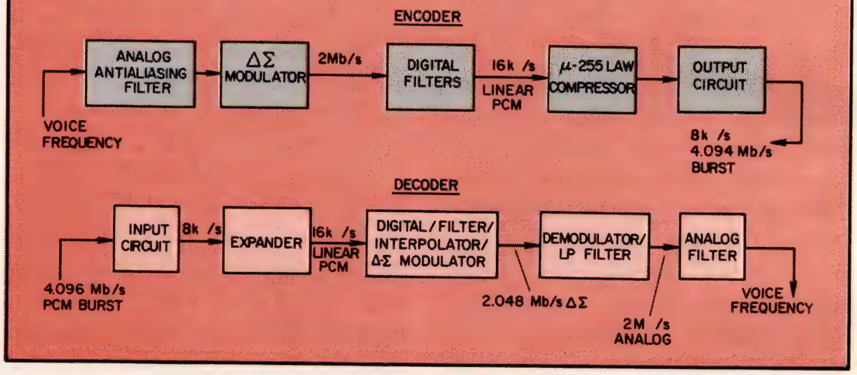
One-chip codec contains filters too

In a departure from the usual companded successive-approximation a/d conversion used in LSI codecs, engineers at Bell Labs (Murray Hill, NJ) have put all the elements required for PCM encoding decoding and filtering onto one chip. In the codec-filter system described by T. Misawa at ICC-80, a delta-sigma (Δ-Σ) modulator linearly encodes analog voice signals at a sampling rate of 2.048 Mbits/s. The high sampling rate translates into simple analog filtering circuitry for antialiasing.

Each high-speed sample produces a 1-bit output that, after multistage successive digital signal-processing, emerges as 16-kbit/s linear PCM. Digital bandlimiting, at each decimation stage, ensures against aliasing errors. The coder compresses the PCM data in conformance to the μ-255 law and delivers 8-kbursts/s of 4.096-Mbit/s pulses.

The decoder digitally processes encoded signals by successively resampling at rates increasingly higher than the original 8-k/s. Meanwhile, it properly interpolates and removes images around integral multiples of 8 k/s. The result is a single-bit Δ-Σ signal occurring 2.048-million times/s. After analog decoding and filtering, the decode section delivers the voice-frequency output.

The codec-plus-filters has been built at Bell Labs with single polysilicon NMOS processing onto a rather large chip—296 × 342 mils. Other codecs that rely on delta modulation include Motorola's (Phoenix, AZ) I^{2}L MC3418 that uses continuously-variable-slope delta modulation and General Instruments' NMOS AY-3-9900. GI plans to introduce a single chip, containing codec and associated filters, based on Δ-Σ modulation (see ELECTRONIC DESIGN, June 7, 1980, p. 115).



Three μPs are better than one in a packet switch, says Mohammad Arozullah of Clarkson College of Technology (Potsdam, NY). In his latest packet-switch design, Arozullah dedicates one μP to each major switch functions: input, routing and output. The three-μP approach breaks the throughput log jam resulting from processor overloads and eliminates the functional interdependence of single-μP designs.

Routing a message begins with buffering all incoming packets. Double buffering and only minimal processing in the buffers reduces the possibility of packet loss due to overflow.

When the input processor finds a full input buffer, it temporarily stores the contained packet in a shift-register array. Here, a second processor—for routing—services the packet. It corrects the header using the BCH error-cor-

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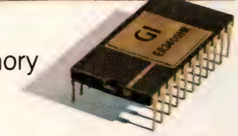
Re-programming Time	11ms	<500ns	15 mins	secs	μs	ms
Radiation Hardness	good	poor	poor	good	good	good
Temp Range	−55°C to +125°C	ltd. by battery	−55°C to +125°C	limited	limited	limited



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recting code that protects each header; determines the packet's destination; and, using the packet's array address, assigns the packet a position in the software output-queue list.

The last processor, the output μP services each routed packet upon finding the appropriate output buffer empty. From the queue list, the final processor gets the array address of the oldest packet awaiting transfer to the empty buffer's associated destination. Once the packet is in the proper output buffer, hardware outside the switch transmits the packet onto the required network channel.

Outside Arozullah's clearly segmented packet switch, the boundaries between data comm and data processing inevitably overlap, says Thomas B. Steel Jr. of AT&T (Basking Ridge, NJ). Telecomm (CCITT) and data-processing (ISO) standard-makers are being forced together by the need for standards for heterogeneous computer systems that communicate over data networks run by common carriers. In particular, Steel foresees the need for telecomm inputs in the higher-level protocols of the seven-layer ISO Reference Model for Open Systems Interconnection (Layered Architecture for Public Data Networks Services, in CCITT terms).

Steel points to the imprecise definition of Layer-4 (Transport). Functionally, it may be contained in Layer 3 (Network) of the CCITT X.25 Recommendation.

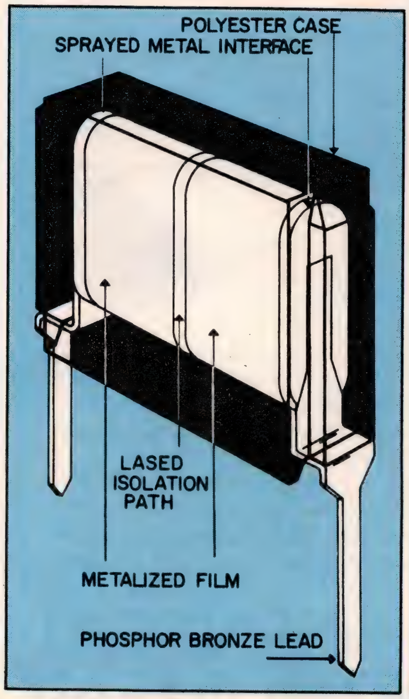
He further cautions data-processing professionals to bear in mind that packet switching is not the only way to interchange data over telecomm facilities. Other systems should not affect the definitions of protocols for Levels 5, 6 and 7, but major differences do exist between CCITT and ISO approaches.

Sid Adlerstein

Laser trimming shrinks Mylar capacitors

Laser trimming the overlapping edges of metallized film dielectrics can produce high-capacitance metallized film capacitors in ultra-small packages, at prices competitive with multilayered ceramics. The LGC process (for Laser-Generated Capacitors) developed by Western Electric (Chicago, IL) can produce capacitance values up to 0.16 μF at 40 V, or high working voltages up to 200 V dc (.0178 μF), in packages little bigger than a two-pin mini-DIP. When licensed to other capacitor manufacturers, the LGC process should cause sharp competition between ceramics and films for capacitor slots on telecommunication and microprocessor boards.

The manufacturing process relies on three recently developed technologies, according to Western Electric Capacitor Development Manager Don Brown: ultrathin polyester-film dielectrics; specialized machinery for tightly rolling metallized polyester; a laser-scoring process which increases the usable dielectric area of capacitors.



Reducing the isolation path practically doubles the capacitance of Western Electric's metallized-film capacitors.

The film employed in Western's capacitor manufacturing operation is 8 and 6-gauge Mylar Type C from DuPont (Wilmington, DE). Specifically formulated for metallized-film capacitors, the 8-gauge Mylar is 0.08 mils thick, while the 6-gauge Mylar is 0.06 mils thick. Metallized Mylar-film capacitors exhibit tight tolerances and good stability over a wide range of frequency, voltage and operating temperature. Unlike other materials which tend to lose their dielectric properties at elevated temperatures, increases in temperature reduce the dielectric strength only by relatively small amounts. At 150 C, the dielectric strength is still 8000 V dc per mil and 6000 V ac per mil. The dissipation factor for Mylar film capacitors is the same at 60 Hz and 3 GHz at 25 C and is seldom more than 1.6% at any frequency or temperature (typically 0.6% at 1 kHz). Dielectric constants are 3.2 to 3.8 in the temperature range from 25 to 125 C.

Although ordinary Mylar capacitors have excellent temperature characteristics, they tend to be much larger than ceramics and frequently higher in cost and have not been widely used in high-speed, high-density signal processing applications. With the introduction of DuPont's 8 and 6-gauge Mylar (ELECTRONIC DESIGN, Dec. 6, 1979, p. 178), however, the situation has changed. For the first time, according to DuPont's Mylar Applications Manager, Edward Fersht, ultrasmall metallized-film capacitors could compete with high capacitance-per-unit technologies such as tantalum and multilayered ceramics.

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velopment, practical micro-sized laser-generated Mylar caps are a reality.

Laser scoring precisely separates the anodes and cathodes of capacitors without removing excess metallized surface. Ordinary processing provides a staggered edge approximately 0.015-in. wide plus a 0.015-in. wide isolation margin on each end. A total of 0.060 in. of metal surface width is unusable. With Western Electric's laser-generation system, a laser shaves off the end metal providing an offset on the order of 0.005 in. plus an isolation margin of 0.006 in. on each end, or 0.022 in. total. Since the total capacitance of the component is related to the usable metal surface area, these small savings in metal surface area provide relatively large increases in the available capacitance—up to twice the capacitance is available in a laser-scored component, compared with the same size capacitor manufactured by conventional methods.

Western Electric is currently in high-volume production on miniature metallized polyester capacitors using DuPont's 8-gauge Mylar. These tiny squares (0.300 × 0.295 × 0.097-in) provide capacitance values up to 0.12 μF at 50 V dc. The high dielectric strength of Mylar helps these capacitors withstand voltage surges up to 150 V, as well as providing self healing in the event of an over-voltage breakdown at much high voltages.

Unlike ceramics which lose capacitance as environmental temperature increases, metallized film capacitors have a tendency to increase in capacitance somewhat with temperature increase. While Western's LGC capacitors will provide an overall temperature-stability characteristic better than X7R, they are specified in a way to reflect the increase in capacitance at high temperatures. At 85 C, for example, the value of a 0.1 μF Western Electric Mylar film capacitor will be equivalent to a 0.2 μF ceramic.

Western is developing 6 gauge capacitors which will be approximately half the volume of the 8-gauge capacitor. Values up to 0.16 μF will be produced at working voltages of 40 V.

The large film capacitors are currently produced in a 2-pin mini-DIP configuration, and are provided in plastic tubes for rapid automatic insertion. The small capacitor will be epoxy-coated with radial leads. Reliability of both types is expected to be on the order of two failures in 1 billion unit hours of operation.

While the LGC capacitors are not available for commercial distribution (only for Bell System use), Western has offered to license the process on a nonexclusive basis to other makers.

Stephan Ohr

Computers prompt a switch to SPS

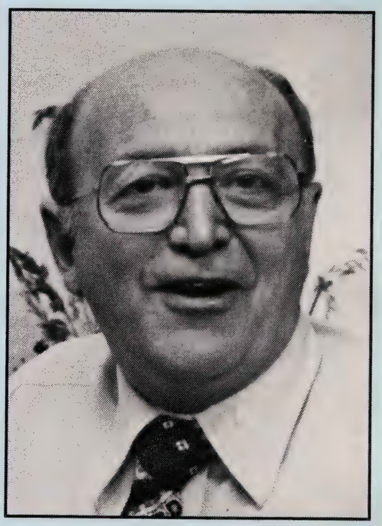
Confidence in the reliability of switching power supplies is on the rise, according to Walter J. Hirschberg, vice president of product development at ACDC Electronics, an independent supply maker. The explosion of the computing industry—which couples low-voltage, high-current switching supplies to digital electronics—is stimulating strong growth in the SPS market.

The main contributors to this growth are the 75% efficiency of switchers (compared to about 40% for linears), the availability of tougher switching and rectifying components, the steady outputs switches deliver over a wide range of input voltages to alleviate brownout fears, and improved engineering know-how.

"The whole secret of circuit design is designing around the imperfections of the components you have to work with," states Hirschberg. "If it weren't for those imperfections, anybody could design a switching power supply." The major objective is to prevent overstress of the switching transistors and rectifying diodes.

With the switching transistor, the design must consider the safe operating area. When turning the transistor off and on, the designer has to avoid simultaneous application of voltage and current across the components or the devices could be destroyed.

With rectifiers, the faster components are more susceptible to



A pioneer in designing modular power supplies, Walter Hirschberg has been involved in rf magnetics since the 1950s. He holds BS and MSEE degrees from the California Institute of Technology, and has been with ACDC throughout its history. He was chief engineer and plant manager for Essex Electronics, which produced rf coils and was absorbed by NYT Electronics in 1956. In 1959, ACDC Electronics was formed out of the NYT complex; it manufactured power and audio transformers. Hirschberg originated and directed development of ACDC's major product lines.

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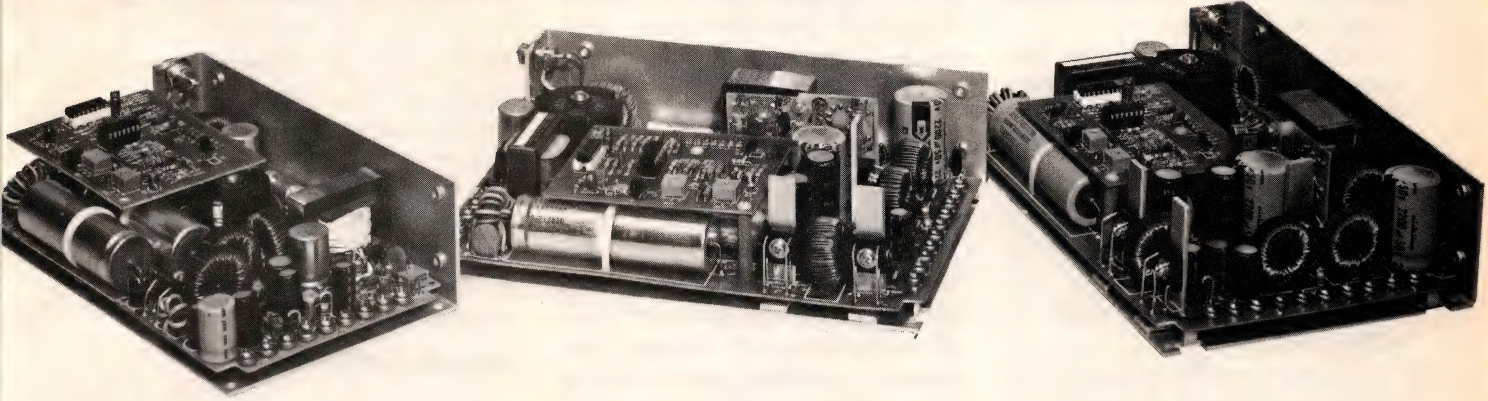

Power/Mate introduces Econo/Switch Multiple Output Switching Power Supplies priced to give substantial savings, yet provide the performance and reliability you depend on in a quality switcher.

The use of Power/Mate's new monolithic chip permits the reduction of parts count by 20% for a much higher MTBF, backed up with a two year warranty. Reliability has been greatly improved by use of computer-aided "worst-case analysis," individual testing of every IC and semi-conductor, and a comprehensive burn-in program.

These carefully packaged units have extremely high component density for maximum wattage per cubic inch. The standard unit has a 5V primary regulated output and two 12 or 15V regulated outputs, plus 5V and 24V semi-regulated outputs. Special units are manufactured to order with voltages specified from 5 to 28V for each of the three regulated outputs and 5 to 50V for the two semi-regulated outputs. Total continuous output power of the unit is 100, 200 or 300 watts. (See charts)

The Econo/Switch multiple output supply gives you exceptional versatility, combined with reliability, efficiency and compactness... at low cost.

Features.

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- **Choice of voltage and current on all outputs up to maximum wattage total.**
- **Voltage adjustable on all regulated outputs.**
- **Brownout protection.**
- **OVP standard on primary output.**
- **Overload protection.**
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- **Adjustable current limiting on regulated outputs.**
- **Meets UL and CSA standards.**
- **Convenient 2-surface mounting.**
- **Convection cooled.**
- **Remote sensing.**
- **Advanced EMI filtering.**
- **Isolated Returns.** (Note 3)

ESM-100 Series — 100 Watts $199.

	Model	Output 1	Output 2	Output 3	Output 4	Output 5	Max. Cont. Output Power
Standard Models	ESM-100-5001	5V@10A	12V@3A	12V@3A	5V@2A	24V@2A	100W
	ESM-100-5002	5V@10A	15V@3A	15V@3A	5V@2A	24V@2A	100W
Customized Models	ESM-100-xxxx	*@10A	*@3A	*@3A	*@2A	*@2A	100W

ESM-200 Series — 200 Watts $319.

	Model	Output 1	Output 2	Output 3	Output 4	Output 5	Max. Cont. Output Power
Standard Models	ESM-200-5001	5V@20A	12V@4A	12V@4A	5V@2A	24V@4A	200W
	ESM-200-5002	5V@20A	15V@4A	15V@4A	5V@2A	24V@4A	200W
Customized Models	ESM-200-xxxx	*@20A	*@4A	*@4A	*@2A	*@4A	200W

ESM-300 Series — 300 Watts $399.

	Model	Output 1	Output 2	Output 3	Output 4	Output 5	Max. Cont. Output Power
Standard Models	ESM-300-5001	5V@30A	12V@6A	12V@6A	5V@4A	24V@4A	300W
	ESM-300-5002	5V@30A	15V@6A	15V@6A	5V@4A	24V@4A	300W
Customized Models	ESM-300-xxxx	*@30A	*@6A	*@6A	*@4A	*@4A	300W

* User specified. Consult factory or local sales office Minimum 250 units
Note 1: Maximum specified current cannot be drawn from all outputs simultaneously. At no time should the average current exceed the maximum continuous output power. Above this point, output voltages and currents will be automatically reduced on all outputs. **Note 2:** Output 1 must be loaded to 15% of total output power to maintain proper regulation of other outputs. (Supply will not be damaged by no-load condition on Output 1) **Note 3:** On ESM-200 and ESM-300 models, all five outputs are isolated. On ESM-100 models outputs 4 and 5 have a common return. All other outputs are isolated

Options: Crowbar up to 8 Amps $8, greater than 8 Amps $16; Add Suffix V to Model No. Cover $10; Add Suffix C to Model No.

Specifications.

AC Input. 95-132 and 190-264 VAC, 47-63Hz.

Regulation. Line — 0.2% within AC limits specified above. Load regulation first three outputs ±0.2%. Load regulation last two outputs ±5%, cross regulation ±3%.

Noise and Ripple. 50mV p-p on first output, 150mV on all other outputs.

Temperature Coefficient. 0.02% per °C on first output, 0.05% per °C on all other outputs.

Efficiency. 65 to 80% typical.

Transient Response. Recovery to 1% in 2 milliseconds for a 50 to 100% load change.

Remote or Local Sensing. Provision included for improved overall regulation.

Overload and Short Circuit Protection. Solid state short circuit protection. Automatic electronic current limiting circuit limits output current to a preset value, thereby providing protection for the load as well as the supply. Units cannot be damaged by prolonged short circuits.

Overshoot. No voltage spikes on turn-on, turn-off or power failure.

Overvoltage Protection. Built in on primary output.

Energy Storage Time. The output voltage will remain within regulation for a minimum of 16 milliseconds after loss of AC input power (from nominal line voltage).

Polarity. May be either positive, negative or floating up to 300 volts DC.

Soft Start. Provides input current limiting at turn-on.

Long Term Stability. 0.1% for 8 hours after 20 minute warm-up.

Ambient Operating Temperature. Continuous duty from 0°C to 71°C. Full rating from 0°C to 50°C, derate linearly to 50% of rating at 71°C.

Storage Temperature. −55°C to +85°C.

Quality Control. In accordance with MIL-I-45208.

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transients, so suppressors are necessary. The very fast Schottkys are especially sensitive to overvoltage spikes, but Schottkys are the most efficient rectifiers available.

The computer industry has been the biggest boon to the SPS. Digital applications have good noise immunity because a ZERO can be anything from 0 to 2 V, and a ONE can be anything from 2.5 to 5 V. The noise of SPSs has little effect on digital circuits, but presents a problem in analog circuits.

Switchers really shine in the efficiency category. With a 5-V output, for instance, a switcher is 70 to 75% efficient, while a linear is only 40% efficient. Above 15 V, switchers are even more efficient (80 to 83%); linears attain about 50% efficiency.

According to Hirschberg, "No one has been able to break through that efficiency barrier to any degree without using rectifiers in the secondary circuit, and rectifiers drop at least 0.6 V."

He also cites losses in the switching transistors, transformer core losses and output filter choke core losses as contributing to the efficiency problem.

Ferrites look good

"We could have a breakthrough in core material. If we could reduce core losses at high frequency and gain large flux densities, then we could wind a transformer with just two, three or four turns. It would then be very easy to construct a high-frequency transformer with a lot of power handling capability." But that breakthrough is not here yet, says Hirschberg. Today's best core materials are ferrites.

Ferrites will probably go into 200-kHz supplies where flux density must be held down to withstand high core losses at high frequencies. Therefore, the transformers will not shrink as much as Hirschberg would like. At 200 kHz, the parameters of parasitic elements (such as leakage inductance and distributed capacity) become more pronounced and interfere with the switching circuit ideal.

The MOSFETs represent a real breakthrough in power transistors, and they have several advantages over bipolar. They switch very fast, they don't add to the switching losses, and they act more like a vacuum tube, which means that voltage, not current, provides the switching drive. Consequently, it takes less power to operate MOSFETs.

Hirschberg also points out some disadvantages. MOSFETs are tempermental about overvoltage and must be protected. One of their main stumbling blocks is that their on-resistance is 0.5 to 1 Ω, when cold; it goes up another 50% when the MOSFETs is hot. Also, at today's high costs, MOSFETs are still not economical at low power levels; suitable bipolars are well established. At higher power levels, the MOSFETs are really out of reach in both availability and price, complains Hirschberg.

But once MOSFETs are available, SPS frequencies can go as high as 200 kHz. At that freqency the size of the SPS is cut in half and the transient response improves because output sampling is ten times faster than at 20 kHz. Frequencies of 300, 400 or 500 kHz create too many problems: more core losses, more problems with parasitic elements which drag down efficiency, and higher internal heat which also compromises efficiency.

Another problem area in switchers is line isolation. Isolation from the power line in a SPS is difficult because all of the switching circuitry is tied directly to the incoming line. "There is no isolation; you just rectify the line and switch it," says Hirschberg. "We've got a lot of electronics sitting right on the line. In a conventional, series-pass regulated power supply, the first thing the line sees is the transformer. A switching power supply needs isolation both in the transformer and in the feedback elements from the output into the switching circuit. It's much more difficult to build a well-isolated high-frequency transformer than a well-isolated 60-cycle transformer."

Isolation is difficult

The smaller the SPS gets, Hirschberg states, the harder it is to get proper high-voltage isolation internally. When the SPS is on the line, efficiency becomes relatively independent of line voltage. The SPS can be just as efficient at a 90-V input as at a 132, 185 or 260-V input. The same is not true of a linear power supply, where input voltage ranges are commonly held to ±10% of nominal. Input storage capacitors also store at higher voltages in SPSs (300 V or so) than in linears, which means that smaller capacitors can generally be used in switchers.

Any digital-based system is a potential application for switchers. "If the end use is digital, a switcher can be used. The OEM user wants to buy a standard product for the reliability that it offers, but he doesn't want a bunch of bells and whistles he can't use."

Hirschberg is dedicated to the whole-line approach. "For the next three to five years, a custom supply maker will be in trouble because the user who was buying a custom the first time out gets stung on delivery time and other problems; but in five years, customs will come back into vogue when switching design becomes more routine."

Ron Shinn

Intel to extend μP family to 32 bits

The growth path marked out by Intel Corp., with its 8085 and 8086/8088-based systems, now widens—as promised earlier this year—to encompass a new generation of LSI processors with address spaces of up to 4 Gbytes and full floating-point math capabilities on-chip. The iAPX 186, 286 and 432 families will be unveiled in stages, as the Santa Clara, CA-based company fills in the outlines already described (ELECTRONIC DESIGN, March 29, 1980, p. 29).

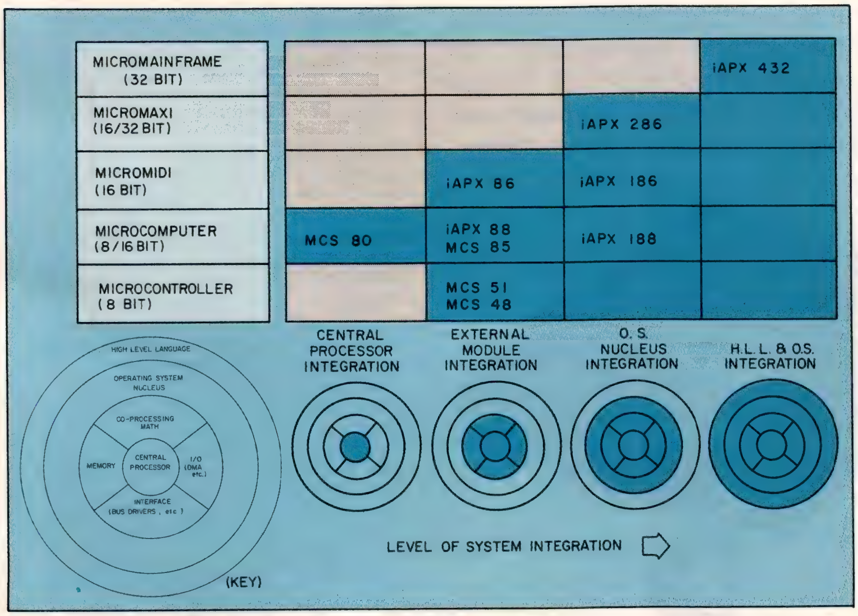
The most powerful of the three families, the iAPX 432, will consist of a multiple-chip set, with each chip housed in a 64-lead quad-in-line package. The capabilities of the 432 Micromainframe will include a direct 32-bit addressing range; full 32-bit integer and 64-bit floating-point support; functionally distributed, message-driven I/O subsystem; virtual memory; multiple operand instructions with vector and record addressing modes; and direct instruction set support for high-level languages.

Through a new architectural concept based on objects, the iAPX 432 integrates high-level languages and operating systems into sillicon.

Next lower in power is the iAPX 286 Micromaxi, a 16-bit processor with many 32-bit features. The processor will offer multilevel software protection, on-chip memory management and protection, high throughput (about five times that of the 8086 family, which is now referred to as the iAPX 86 family), 1 Gbyte of virtual addressability per task, 16 Mbytes of direct addressability, an integral operating system kernel and an instruction set that builds on the sets for the iAPX

EXAMPLE INSTRUCTIONS	IAPX 286/IAPX 86
MOV REG TO MEM	>6.4X
ADD REG TO MEM	>4.8X
MUL REG 16	>8.5X
DIV REG 16	>10X
SHIFT/ROTATE MEMORY	>5.8X
CONDITIONAL JUMP	2-2.7X
BLOCK MOVE	>4.5X

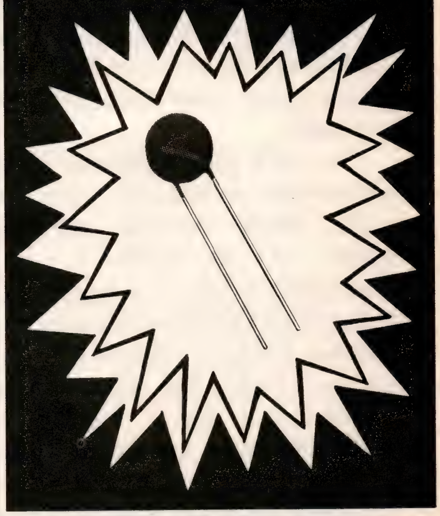
The iAPX 286 has about five times the throughput of the earlier 8086 μP.



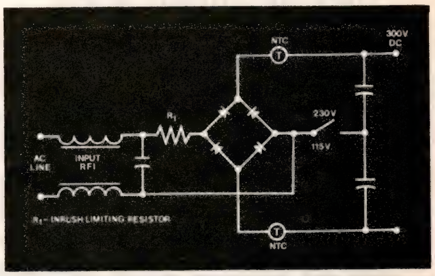
With the unveiling of the iAPX 432, 286 and 186/188, Intel adds to its growing μP family. The most powerful, 32-bit micromainframe, integrates high-level languages and operating systems on-chip.

Keystone

INRUSH CURRENT LIMITERS



Turn to Keystone to protect your switching power supplies from turn-on surge...as diagramed below.



Keystone has designed special disc-style NTC thermistors with crossed leads in eight types with "cold" resistance values @ 25°C from 0.712 to 120 ohms.

Send for Bulletin P-780

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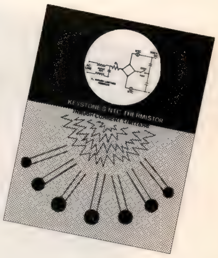

Keystone
CARBON COMPANY
Thermistor Division
St. Marys, PA 15857
814/781-1591 • Telex 91-4517

CIRCLE 19

86/88 families of µPs.

As an evolution of the iAPX 86 microprocessor, the 286 central data processor features two operating modes—a native instruction set and an emulation of iAPX 86 commands. It executes code five times faster than the iAPX 86 processor.

The iAPX 186/188 Micromidi is object-code compatible with the iAPX 86/88 families, yet upgrades the development path. Both units represent a horizontal integration of CPU-associated resources and offer 1 Mbyte address spaces, on-chip bus interfaces of master and slave, high-speed DMA channels, integrated programmable timers, on-chip multiple-input interrupt controller and built-in debug support.

Dave Bursky

Thin-film media adds density to rigid disk

Employing the same software addressing techniques as 5-1/4-in. minifloppies, a novel 5-1/4-in. Winchester disk comes with both ferrous oxide and thin-film media. By deciding on a thin-film media (NiCo), New World Computer Company (Costa Mesa, CA) increased disk density to 12,000 bits/in., compared to about 10,000 bits/in. for ferrous oxide.

The MINIMIKRO-DISC V-1TF drive makes New World the second company with a 5-1/4-in. Winchester disk drive, following Shugart Technology (Los Gatos, CA) (ELECTRONIC DESIGN, April 26, 1980, p. 31). The New World unit stores 1.3 Mbytes, and transfers data at 6.78 MHz. Its software compatibility with minifloppies develops from similarities in the disk files. In the 5-1/4-in. drive, eight heads track 40 sectors; in a typical minifloppy, the files have eight sectors and 40 tracks.

The eight read/write heads are part of an assembly that contains 128 tracks/surface and that places the storage capacity of a 5-1/4-in. floppy disk drive immediately beneath the heads at all times, accessible within one disk rotation. The average data access is therefore 8 ms, which compares favorably with 8.2-ms access times for most bubble memories and 40 to 70-ms access times for 8-in. high-performance closed-loop servo drives.

New World plans to lower the OEM price of the MINIMIKRO-DISC V-1TF from $700 to $500, by incorporating readily available components and cutting its weight from 3 lb to 2 lb. Future drives will gain automatic actuators and other innovations.

The New World Computer 5-1/4-in. drive (left) will be available with both ferrous-oxide and thin-film media. Average access time is 8 ms.

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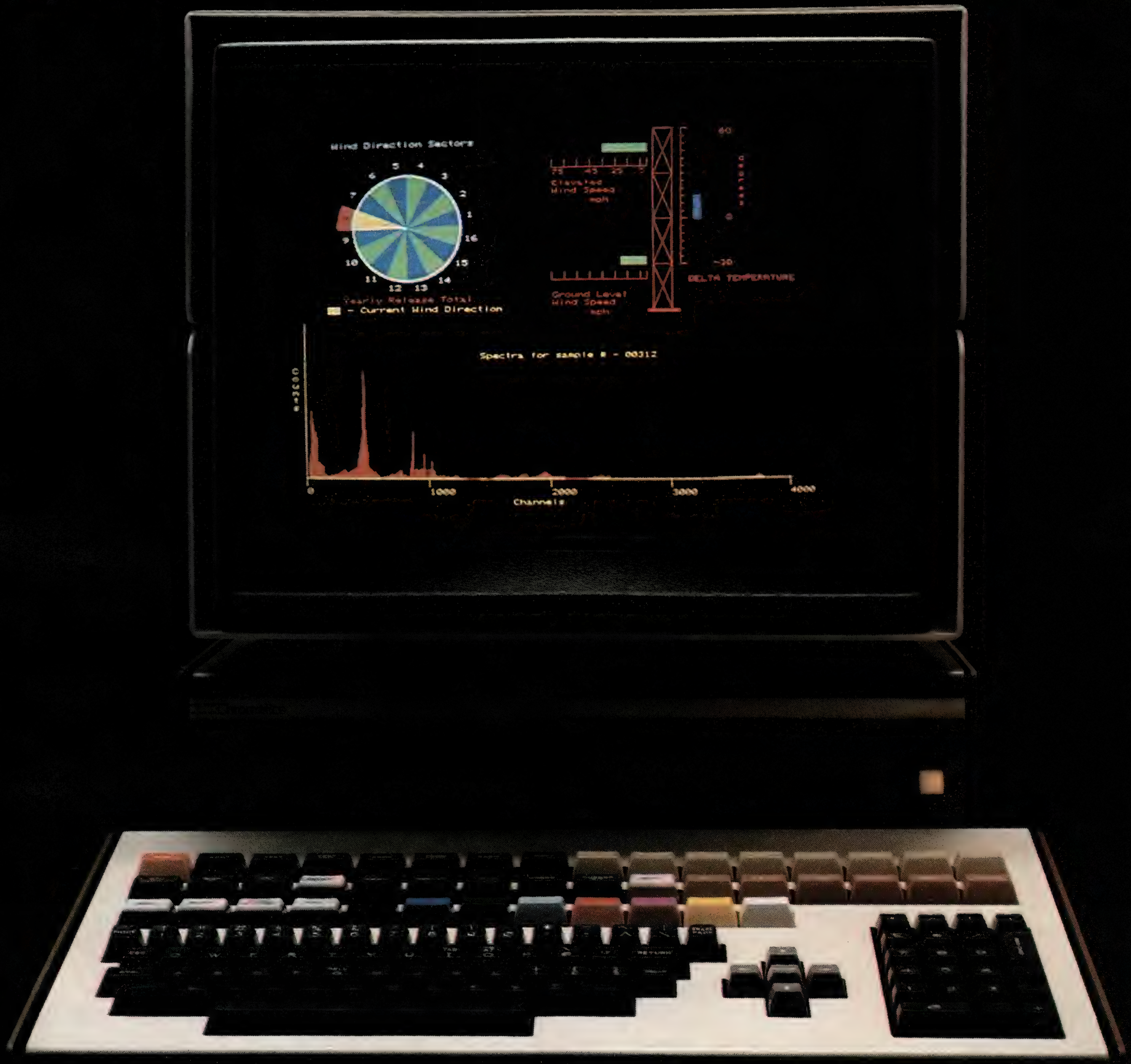

There's no question about it: Our CG 3999 color graphics computer provides high 512 x 512 resolution at the very lowest cost anywhere – just $5995. You not only get 512 x 512 individually addressable and individually color defined dots, you also get the brightest color in the industry, as well as flicker-free 60 Hz non-interlaced images. And for only $895 more, you can add the full keyboard pictured above.

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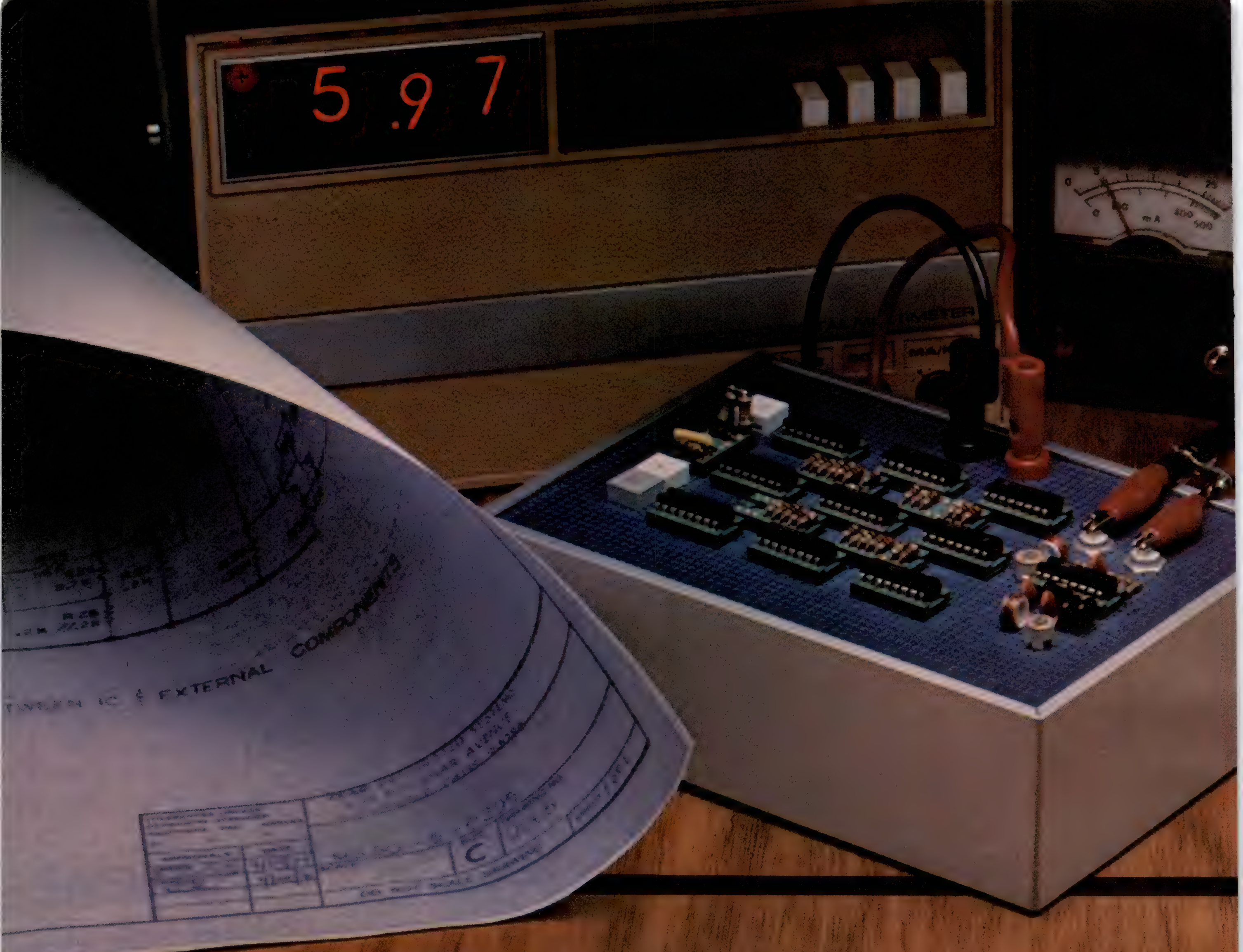
CIRCLE 20



In weeks Exar can into a custom

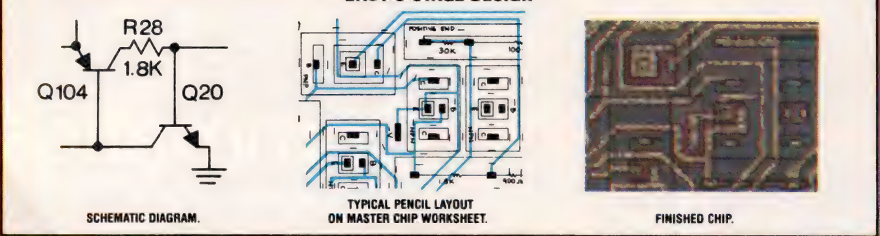
Cut up to one year off development time on linear custom circuits, reduce costs, and avoid design errors.

Exar's standardized semi-custom Master Chips contain undedicated NPN and PNP transistors, resistors, Schottky diodes, and bonding pads. You interconnect these components to create your own custom circuit. Development time compresses drastically, becomes far less expensive and virtually risk free. Exar's alternative source agreements with other IC manufacturers let you specify and order custom circuits with confidence.

Go to full custom later.

As your product matures and your need for circuits increases, Exar can convert your semi-custom chip to a full custom IC, reducing chip size, saving money, and often providing added performance.

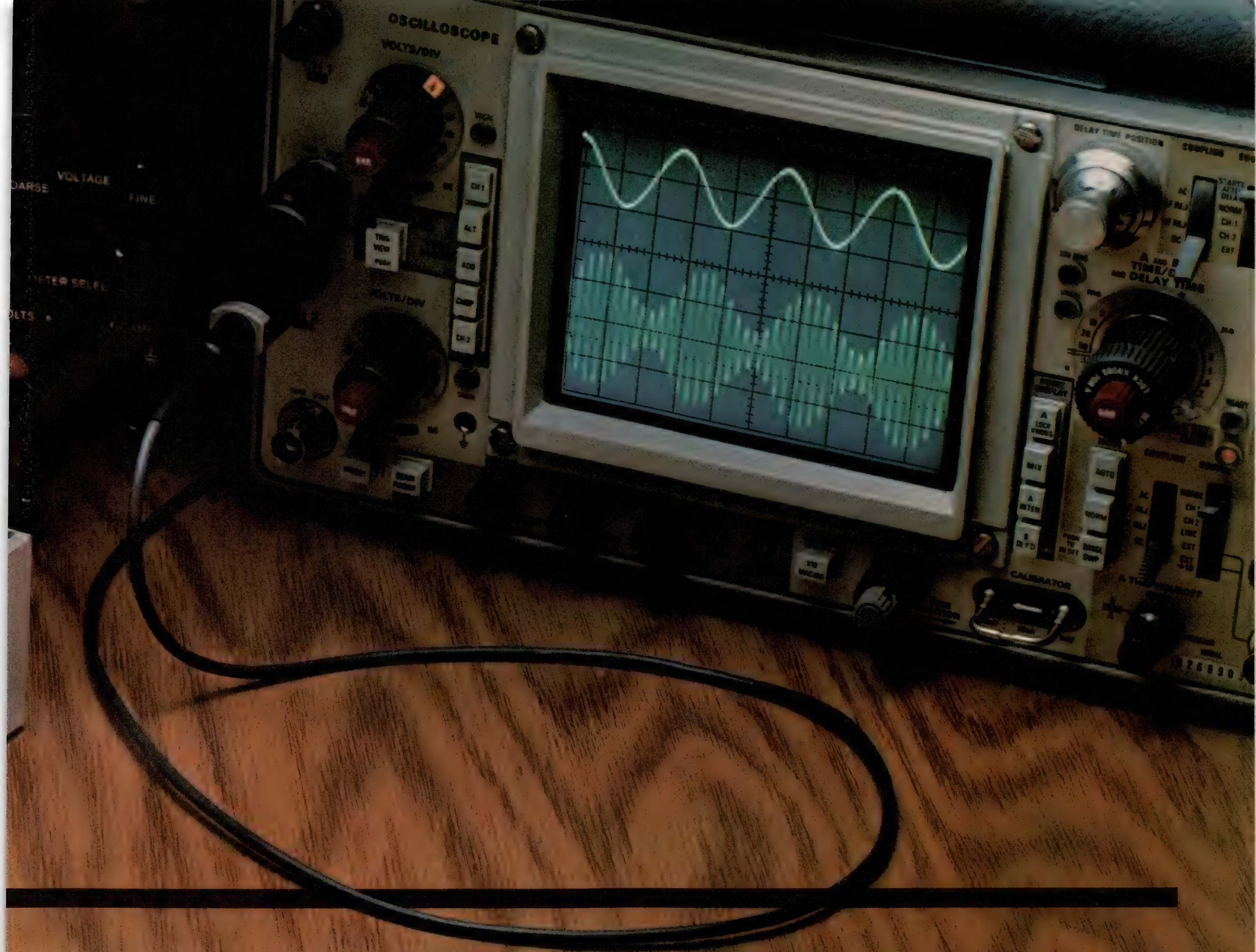
EASY 3-STAGE DESIGN



SCHEMATIC DIAGRAM.

TYPICAL PENCIL LAYOUT ON MASTER CHIP WORKSHEET.

FINISHED CHIP.



transform your design linear circuit.

Choose from seven linear chips.

Chip Type	Transistors		Schottky Diodes	Resistors	Bonding Pads	Second Source
	NPN	PNP				
XR-A100	59	18	15	159	16	YES
XR-B100	69	12	16	191	24	YES
XR-C100A	22	8	6	71	14	YES
XR-D100	50	16	0	126	16	YES
XR-F100	96	36	0	296	24	YES
XR-G100	60	18	0	223	18	YES
XR-J100	38	12	0	116	18	YES

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They combine digital circuits with high density I^2L logic arrays and bipolar transistors.

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Exar's design kits include circuit components for breadboarding, a comprehensive design manual, and layout worksheets corresponding to Exar's Master Chips.

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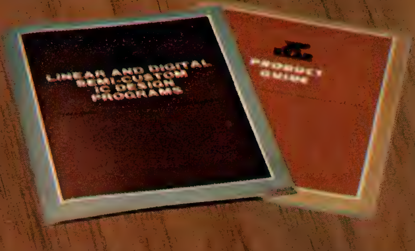
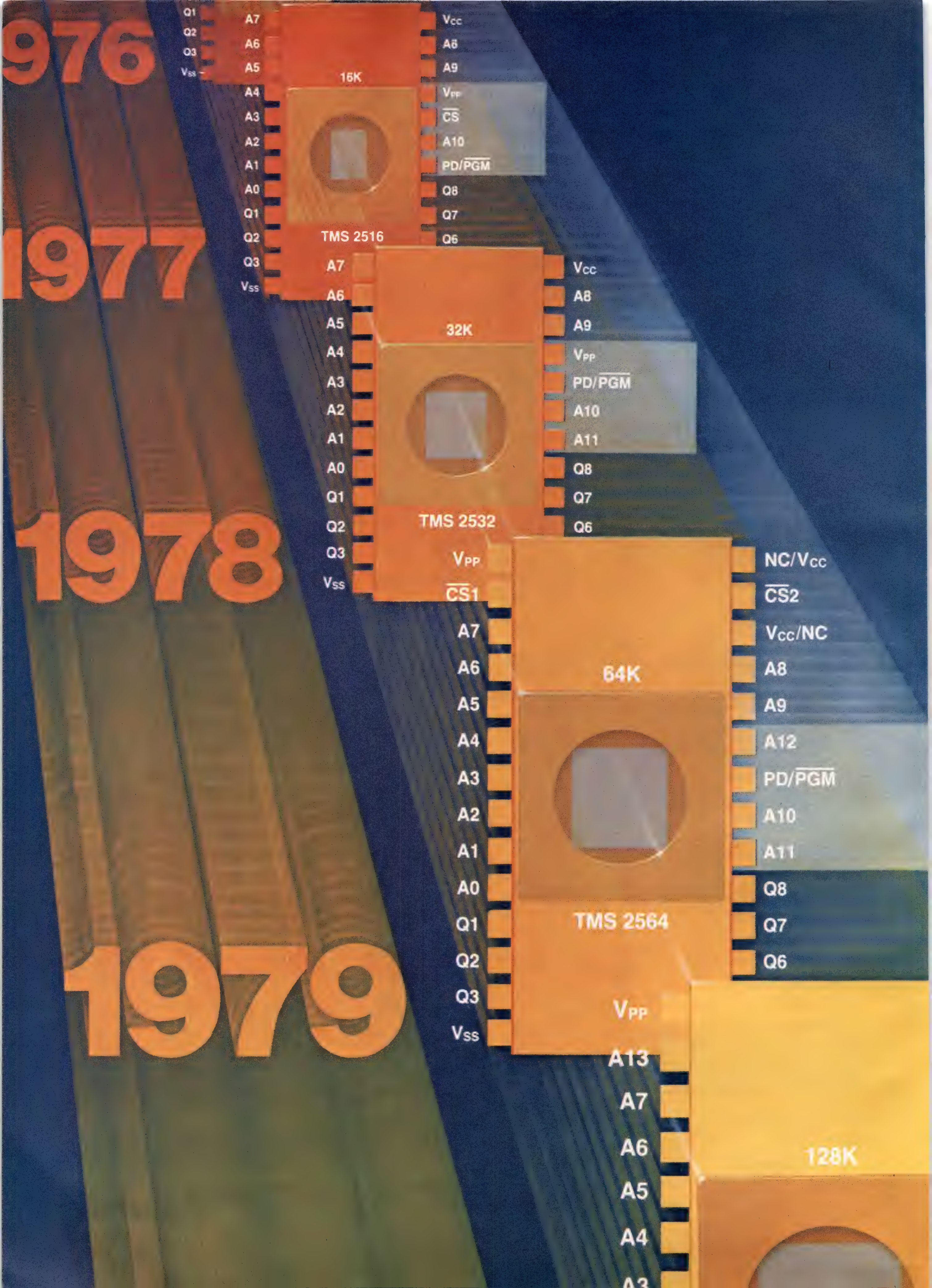


EXAR

CIRCLE 21


976
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Q2
Q3
VSS
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A6
A5
A4
A3
A2
A1
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VSS
16K
TMS 2516
VCC
A8
A9
VPP
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PD/PGM
A10
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1979
VPP
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A4
A3
128K

64K EPROMs from Texas Instruments. Defining the future. Ready today.

EPROMs regularly double in density — 128K devices are inevitable. By factoring TI's new 64K EPROM into your plans today, you can pave the way for these greater densities and minimize system redesign.

Because the new TMS2564 comes in a 600-mil, 28-pin, dual-in-line package. Plug compatible with that anticipated for the 128K EPROMs ... and ROMs. When the time comes to upgrade, you'll be able to substitute one for the other.

Outstanding compatibility

In the meantime, the TMS2564 EPROM allows you a great deal of latitude. For maximum compatibility with present devices, its pinout is derived from the popular, industry-standard 24-pin 64K ROM supplied by eight sources.

On the new TMS2564, pins 26 and 28 are reserved for the 5-V supply. With a supply trace to pin 26, both 24- and 28-pin devices can be used with no jumpering. If you choose, you can even use smaller EPROMs without compatibility problems. And upgrading from the TMS2532 32K EPROM is a snap.

Low power

The TMS2564 offers you the lowest power per bit in the industry ... only 13 μW max active. A must for high reliability and low system operating costs.

Widest choice

Adding the TMS2564 to our fast-growing EPROM family gives you a choice unmatched in the marketplace. All members are available in 600-mil packages with industry-compatible pinouts. All share the reliable production-proven TI EPROM technology.

Here now

TI's TMS2564 has been in production since mid-1979. No need to wait — place your order today for the industry's first 64K EPROM, from the industry's first supplier of 16K and 32K EPROMs. Check your nearby TI sales office or authorized distributor. Or write Texas Instruments Incorporated, P.O. Box 1443, M/S 6965, Houston, Texas 77001.

Fifty Years of Innovation

PACESETTING EPROMs FROM TI

Device	Description	Power Supply	Typical Power (0°C) Operating	Typical Power (0°C) Standby	Access Time
TMS2564	64K	5 V	400 mW	50 mW	450 ns
TMS25L32	32K	5 V	325 mW	50 mW	450 ns
TMS2532	32K	5 V	400 mW	50 mW	450 ns
TMS2516-35	16K	5 V	285 mW	50 mW	350 ns
TMS2516	16K	5 V	285 mW	50 mW	450 ns
TMS2508-25	8K	5 V	250 mW	50 mW	250 ns
TMS2508-30	8K	5 V	250 mW	50 mW	300 ns
TMS2716	16K	+12, ±5 V	315 mW	—	450 ns
TMS27L08	8K	+12, ±5 V	245 mW	—	450 ns
TMS2708	8K	+12, ±5 V	690 mW*	—	450 ns
TMS2708-35	8K	+12, ±5 V	690 mW*	—	350 ns

*T_A = 70°C

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CIRCLE 22

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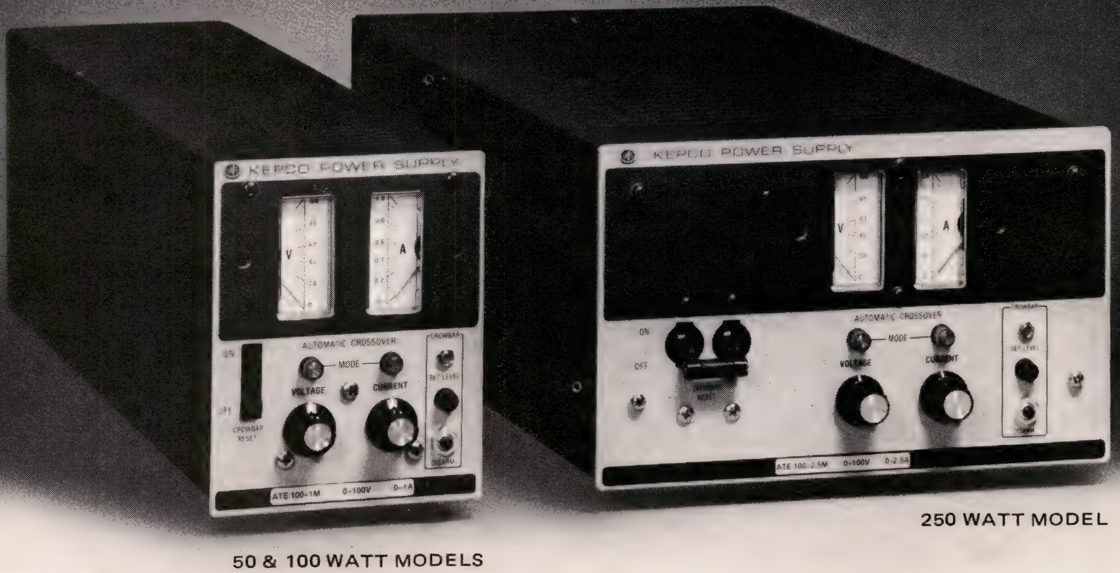

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CIRCLE 23

WashingtonReport

FCC's AT&T ruling draws its first opposition

The Computer and Communications Industry Association wants a review of the FCC decision to deregulate enhanced telecommunication services and terminal equipment. The ruling would permit AT&T to enter the data communications and data processing markets through a separate subsidiary. By 1982, the giant telephone company would be in direct competition with smaller terminal equipment manufacturers.

CCIA is the first organization to challenge the FCC ruling, in the U.S. Court of Appeals for the District of Columbia. However, the U.S. Justice Department is also eyeing the FCC order. The order may permit AT&T to violate the terms of the 1956 consent decree, which bars the phone company from the data processing market. Expert opinion around Washington is that the consent decree may very well be dead.

The court ruling on the commission order will be crucial. Should it overturn the commission, AT&T would have to get action from a balky Congress before it could enter the data communication market, a feat it so far has been unable to accomplish.

GSA reorganizes computer procurement office

The General Services Administration, which does most of the government's buying, will reorganize its Automated Data and Telecommunications Service (ATDS) "in response to the rapidly changing information technology field." Plans call for streamlining the procurement structure and creating a decisionmaking group of four persons.

ATDS Commissioner Frank Carr announced the creation of three new offices: an office of policy and planning, an office of software development and an office of program management. The policy and planning staff will make sure that the government's regulations and services meet the needs of various agencies and are integrated with the equipment and services available in the marketplace. Policy and technical guidance questions regarding software will be handled by the software development office. The program management staff will handle the day-to-day procurement activities, assist the government's agencies in data processing management and conduct research. Financial management and budget activities will be delegated to an executive director's office.

ATDS has governmentwide authority over the management, procurement and use of automated data processing and telecommunications equipment, software and services.

Soviets may have a laser ASAT

U.S. military research programs into laser weapons and antisatellite devices are in their infancy, but the Soviet Union may already have a practical laser "gun" that can hit low-altitude satellites. Reports to that effect—some of them attributed to White House intelligence estimates—indicate that the Soviet laser system is ground-based; an orbiting laser weapon may also be under development. A space-borne laser could hit military and communications satellites orbiting at higher altitudes.

SBS demonstrates telecopier system

Satellite Business Systems has given the first demonstration of its high-speed telecopier system at the firm's headquarters near Washington.

The system uses a send-receive terminal specially designed by AM International of Los Angeles. The terminal can send up to 4200 copies per hour and can store data for automatic transmission during off-peak hours.

The SBS consortium was organized by IBM, Comsat and Aetna Life and Casualty to market satellite-based business communications services. Its service package includes the telecopying, data transmissions between computers, voice communications and teleconferences, all by satellite. Eight major corporations have signed up for the SBS service, according to a spokesman for the firm, with more expected by the time the first regular transmissions take place next January. The first SBS satellite will be launched this fall.

To spur interest, SBS officials are working on a modified version for the many smaller businesses which cannot afford their own satellite earth stations. The concept calls for a central earth station linked to several participating firms by regular telephone lines—with FCC approval. Also, unlike the larger companies, the smaller firms may buy portions of the SBS service rather than the entire four-service package.

Information industry will measure itself

The Information Industry Association, a Washington-based trade organization, will undertake an annual industrywide survey of manufacturers and companies that produce information equipment, from word processors and digital equipment to satellite earth stations. The results should help companies in the field assess their market standing and adjust their marketing plans.

The blind survey, now underway, will include data for 1979 and estimates for 1980 on employment, growth levels, new areas of exploration, product lines, markets served, foreign sales and overall financial pictures.

Fewer consumer electronics enter the U.S. in first quarter

Despite increases exceeding 200% in some areas, the unit imports of consumer electronic products into the U.S. declined 17.3% during the first quarter of 1980. According to the Consumer Electronics Group of the Electronic Industries Association, import declines occurred in color televisions, auto and home audio tape players, home radios, record players, record changers and turntables.

Color television imports fell the sharpest: 50.7%, from 422,359 units in the first three months of 1979 to 208,245 units in the first quarter this year.

Electronics products for which imports increased include monochrome television (up 17.5%), tape recorder/player combinations (up 17.9% for audio and 81.6% for video) and phonographs (up 226.1%).

Capital Capsules

The Electronic Industries Association's Imports Committee has asked for an injunction against the government's settlement of dumping claims against Japanese manufacturers. Joined with the Committee to Preserve American Color Television (COMPACT), the EIA has placed its suit before the U.S. Court of Appeals for the District of Columbia. The Commerce Department and U.S. Customs Service agreed to accept $75 million in settlement of the dumping claims. U.S. firms want the Japanese firms to pay $400-700 million.... **The Air Force is initiating a development program for integrated software support** to improve the software development process for avionics systems. Present plans call for two yet-to-be-selected contractors to handle the project during its first phase....The engineering department at **EIA has revised the standard for acceptance testing of radio receiver speakers** and phasing of receiver loudspeakers. Under the new standard, vendors and users can more easily determine speaker parameters and tolerances and will get methods of measurement at incoming inspection. The document (RS-276-A) is available from EIA.

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Flexibility.

You can buy the system that meets your needs today, and add to it anytime. We'll work with your engineers to assure you aren't buying more or less than you need.

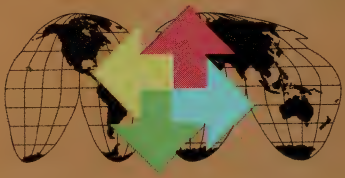
Easy to use.

Only one language to learn. All three systems use TEKTEST, a test-oriented language very close to English. Your test engineers will quickly generate, edit, and debug device-testing programs. And with the Computer Aided Program Generation option, they'll easily generate many test programs. All systems feature highly advanced data reduction and graphics, making test results manageable and easily understood.

Training.

We'll support your test engineers with a comprehensive training program and thorough documentation.

Worldwide support.



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CIRCLE 152

ElectronicDesign

INTERNATIONAL

June 21, 1980

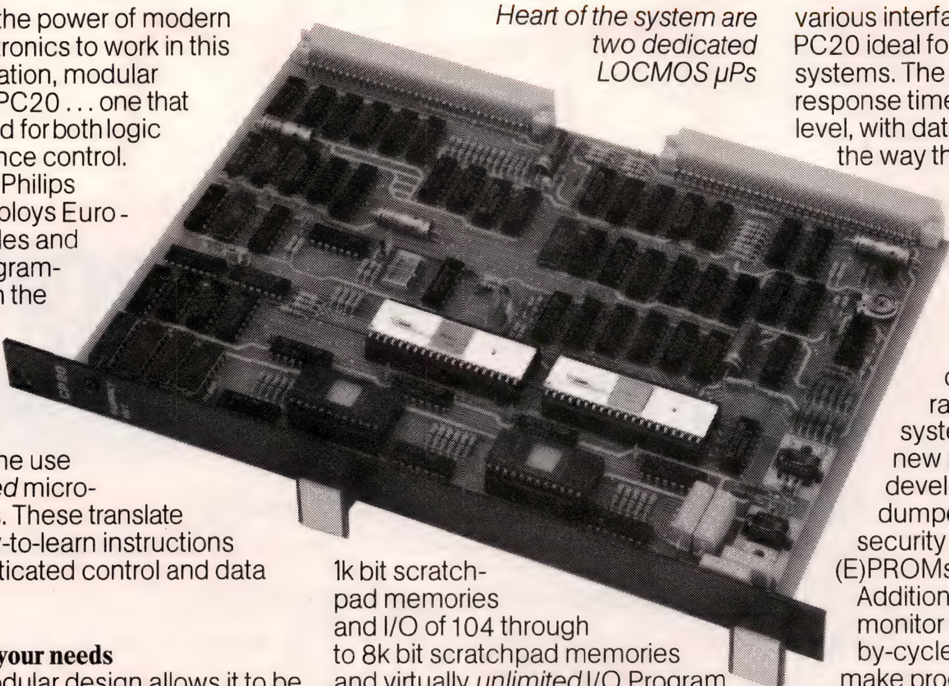
Oscilloscope calibrator automates testing

μC board boosts performance but not cost

Transient recorder offers flexibility plus economy

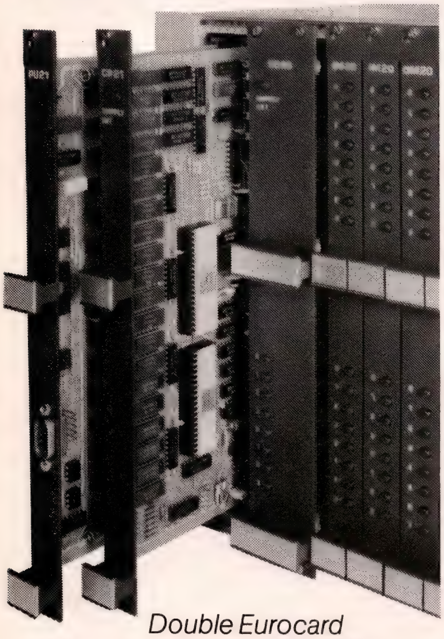
COST/PERFORMANCE BREAKTHROUGH IN PROGRAMMABLE CONTROLLERS

Dedicated µPs cut costs, boost performance and simplify programming


Heart of the system are two dedicated LOCMOS µPs

Philips put the power of modern micro-electronics to work in this new-generation, modular system . . . PC20 . . . one that can be used for both logic and sequence control. Like earlier Philips PLCs it employs Euro-card modules and simple programming, but in the new system this is taken one step further by the use of *dedicated* micro-processors. These translate basic, easy-to-learn instructions into sophisticated control and data functions.

Tailored to your needs
PC20's modular design allows it to be cost effective across a wide spectrum of applications . . . from systems with 1k bit scratch-pad memories and I/O of 104 through to 8k bit scratchpad memories and virtually *unlimited* I/O. Program memories range from 1k to 8k words in RAM or (E)PROM. A common feature of all systems is the 1 ms cycle time for a typical 1k program memory . . . *currently the fastest around* . . . plus high noise immunity and a single 10 V power supply. These big benefits are the result of using Philips LOCMOS LSI's.


Double Eurocard modules make for easy installation

Hierarchical systems
The fully modular design and the various interface cards make the PC20 ideal for hierarchical control systems. The correct capacity/response time can be provided at every level, with data communications all the way through to a central facility.

Versatile programming aids
Programming is carried out by the illustrated table-top unit and an interface card that fits in the PC rack. The programming system is highly versatile: new programs can be developed on RAMs . . . dumped onto cassette for security and transferred to (E)PROMs for series production. Additionally it can be used to monitor operation, either cycle-by-cycle or continously and to make program updates and modifications. Program printouts or VDU displays can also be provided.

For full details on this breakthrough in programmable controllers use the reader service number below or write to:

Philips Industries,
Electronic Components and
Materials Division,
Eindhoven, The Netherlands.

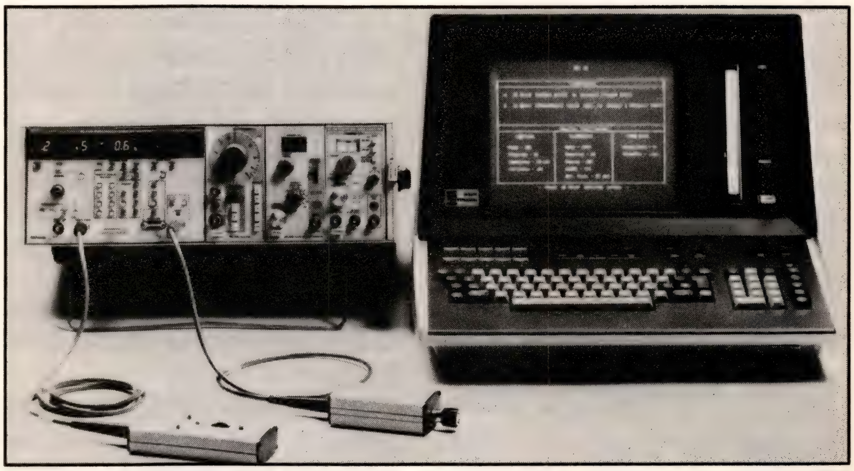
Desk-top programming unit

PHILIPS
Electronic
Components
and Materials

CIRCLE 153

PHILIPS

Oscilloscope calibrator automates testing



The CG 551AP programmable oscilloscope-calibration generator from Tektronix International offers scope users an alternative to conventional maintenance—automated testing and calibration. It can calibrate and verify major oscilloscope parameters with little help from the operator.

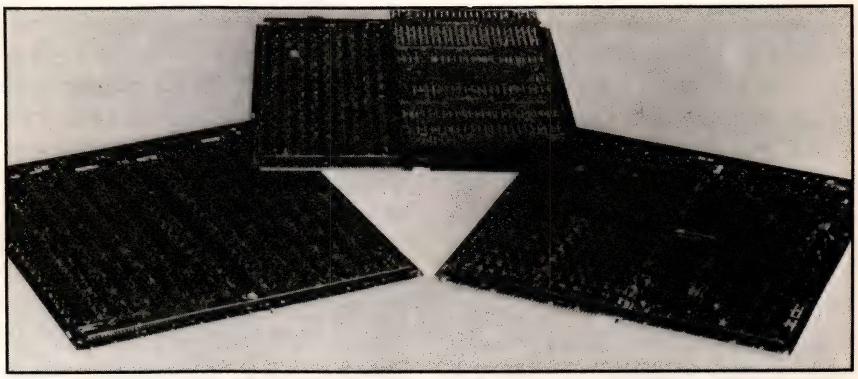
The system provides step-by-step operator instructions and automatically generates the proper type and sequence of test and calibration signals. System software in the form of the company's Scope Cal Procedure Development Aid (SCPDA) program takes over much of the measurement of oscilloscope error as well as comparisons with the user's permissible standards.

The CG 551AP is designed to be an integral part of a system using an IEEE-488 bus. Typically, the unit will be part of a system that includes a controller for program development and execution and hard-copy or line printers for automatic documentation.

SCPDA takes the guesswork out of programming. A technician answers a series of controller-prompted questions. The front panel is used to set up each test condition. SCPDA takes the answers and front-panel settings during the CG 551AP's "learn" mode and forms a program for the unskilled operator.

Tektronix International, P.O. Box 827, 1180 AV Amstelveen, The Netherlands. 020-471146. Telex: 18312/18328. **CIRCLE 501**

μC board boosts performance but not cost



The NM4/95 minicomputer board system from Computer Automation improves significantly on the performance of the NM4/90 but without significantly increasing the cost. The eight-register, 16-bit system has complete memory-management capability for up to 8 Mbytes of error-correcting memory and high-speed cache. What's more, the NM4/95 uses existing software, I/O interfaces and controllers, so current NM4/90 users can upgrade easily and economically.

A memory-management unit gives the NM4/95 address-translation capability, allowing memory addressing to expand up to 8 Mbytes. The MMU also provides page-access protection and recording for each 2-kbyte page of its read/write memory.

In addition, the MMU contains a 2-kbyte cache with a 50-ns access time and a typical hit rate of 85%. Effective access time slows to 150 ns when the cache is used with a new error-checking and correcting 580-ns RAM.

All told, with 128 kbytes of RAM plus the MMU/cache, the NM4/95 works approximately 20 to 25% faster than the NM4/90 with equivalent memory.

Computer Automation, Hertford House, Maple Cross, Rickmansworth, Herts. WD2 2XD, England. Rickmansworth 71211. Telex: 922654. **CIRCLE 502**

Transient recorder offers flexibility plus economy

A two-channel transient recorder from Data Laboratories does more than provide dual-channel waveform storage with a wide range of recording and triggering modes. As part of the company's 900 series, the DL902 shares existing accessories and interface options, to make its £1350 price even more attractive.

Flexibility is the key word. The DL902 may be used as a high-resolution oscilloscope storage accessory, as a high-speed waveform-capture device for slower recorders, or as a waveform digitizer for a desktop computer or a minicomputer.

Both recording channels can be filled simultaneously with waveforms from separate signal sources via independently variable, high-impedance input amplifiers. Each channel consists of a 2048 × 8-bit memory, giving the instrument 0.4% vertical and 0.05% horizontal resolution.

Each waveform is digitized by a monolithic a/d converter capable of a maximum sample rate of 1 MHz. This makes the DL902 useful for recording signals containing frequencies up to 250 kHz.

Waveforms digitized and stored in the DL902 are automatically reconstituted to analog form for viewing as two separate traces on any single-beam oscilloscope or a YT or XY chart recorder. Subsequent processing of the digitized data is facilitated by a built-in interface, accessible via a 24-way connector located at the rear of the instrument. A binary-coded word-serial, bit-parallel asynchronous interface is standard, but may be replaced by plug-in interfaces for RS-232 and IEEE-488 compatibility.

Split time-base operation allows a recording sweep to change speed at a predetermined point during recording. Each channel incorporates a "hold" facility, allowing recorded information to be preserved for reference purposes while new records are taken in the other channel for comparison.

Data Laboratories, 28 Wates Way, Mitcham, Surrey CR4 4HR, England. 01-640 5321. Telex: Datalab 947680. **CIRCLE 503**

Op amp comes through hazardous environments

A general-purpose operational amplifier, OPA 11HT, meets its performance figures, even at the temperature extremes of −55 to +175 C. Manufacture of the device to military standards and rigorous inspection procedures results in a device capable of performing in hazardous environments. Features include a minimum open-loop gain of 98 dB into a 2-kΩ load, a wide bandwidth of 50 kHz minimum at full power, a minimum current output of ±10 mA, a bias current of ±40 nA maximum and a 100-dB common-mode rejection. The output of the device is current-limited to provide short circuit protection.

Burr-Brown International Ltd., Cassiobury House, 11-19 Station Rd., Watford, Herts WD1 1EA, England. Watford (0923) 33837. Telex: 922481.

CIRCLE 504

Software turns floating point to decimal ASCII

A software package, 9511 Conversion Routines, converts the floating point format of the 9511 arithmetic chip from and to decimal ASCII representations. Conversions from 32-bit integer format to decimal ASCII (and vice versa) are also supported. Conversion routines are optimized for speed. For example, float to decimal requires only 2.2 to 23 ms; decimal with exponent to float, 1.5 to 11 ms; integer to decimal, 0.5 to 3.9 ms; and decimal to integer, 0.3 to 2.2 ms. Execution times shown are for an 8080 microprocessor. Times for an 8085 microprocessor are approximately 40% faster. The conversion routines are supplied in EPROM, Isis II file or paper tape.

Sorenson Software, Raiffeisenstr. 1, D-6104 Seeheim, West Germany. 06257-83707.

CIRCLE 505

Interface puts controller on IEC bus

A built-in IEC bus interface adapts the PTC temperature meter for use in automatic measurement and control systems. The controller measures temperature over a platinum resistance thermometer with a four-wire circuit. Accuracy is within 0.2° while resolution of 0.1° is offered through the unit's −100 to +300 C range. Temperatures detected with a sensor are compared with a set nominal value. A control signal, derived from a comparison, is used to switch a load relay or a control relay. A four-digit display indicates actual or nominal temperature in C or K.

Rohde & Schwarz GmbH, Mühldorfstr. 15, Postfach 80 14 69, D-8000 Munich 80, West Germany. (089) 41292625. Telex: 523703.

CIRCLE 506

Check Out the TEAC Floppy Disk Trio

High-Reliability 5¼" Floppy Disk Drive Series

For convenient data storage on small computer systems, nothing can compete with floppy disk. The new, smaller, 5-1/4 inch floppy disk drives have become especially popular because of their convenience and cost performance. Using its accumulated recording equipment and computer peripheral technology, TEAC has developed its own 5-1/4 inch drives with reliability, access time, and features that are superior to the competition.

FD-50A

Single-Track-Density

The FD-50A is TEAC's basic single-sided, single-density model. It is fully compatible with the Shugart SA 400, but head load and access times are about twice as fast. In addition to the usual FM recording format, the MFM and M²FM recording formats can also be used, effectively doubling the disk's capacity.

FD-50C

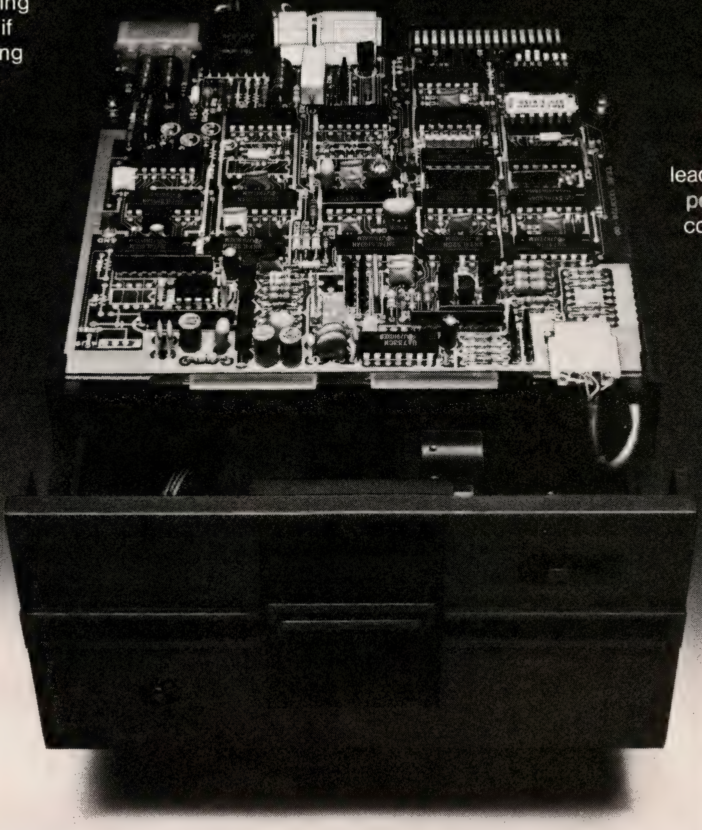
Double-Track-Density (100 Tracks/Inch)

The FD-50C is a double-density-track version, compatible with the Micropolis 1015 Model II. It uses a 100-track/inch format, for more than double the capacity of the 48-track/inch FD-50A. And as with the FD-50A, MFM and M²FM recording formats can be used if desired, further doubling the disk's capacity.

FD-50E

Double-Track-Density (96 Tracks/Inch)

The FD-50E is another double-track-density model. FM, MFM and M²FM recording formats may be used, allowing a total capacity of up to 500K bytes. The interface specification comprise with proposed ANSI standards.



Reliable, Noiseless, Brushless Motor

TEAC used an extremely reliable brushless motor in these drives, making them the most reliable 5-1/4 inch floppies produced yet. Because the motor is so reliable TEAC engineers decided to have it run continuously, eliminating the motor start-up time.

Precision Head Seek

A high-precision lead screw method is used for positioning the head to the correct track. The improved positioning accuracy greatly reduces the possibility of a data error.

TEAC®

TEAC CORPORATION: 3-7-3 Naka-cho, Musashino, Tokyo, Japan Tel: (0422) 53-1111

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CIRCLE NO. 154

Logic Analysis Made Easy.

At last. Logic analysis made easy. When digital and analog worlds meet the relationship between state and timing analysis becomes critical. Now Philips helps you capture and examine this relationship instantly—with the two most original logic analyzers on the market.

Both instruments offer optimal performance in fault location and analysis, combined with unmatched operating simplicity. Isn't it about time someone offered you the best of both worlds? Why not choose your digital troubleshooter today?

The PM3500 100MHz 16 Channel Logic Analyzer

- Performs both state and timing analysis
- Can spot 3ns glitches
- Choose binary, hex, octal, mapping or timing display modes
- 504 X 16 bits memory format
- Internal and external triggering with trigger extension facilities
- Handles all logic families
- Compare mode facilities
- Tiny input probes matched for 100MHz operation can be grouped or used separately—even meters apart

The PM3540 10MHz Logic Analyzer and 35MHz Real-Time Scope

- Unique matched combination of state analyzer and oscilloscope
- Accepts 16 data channels and 2 real-time channels
- Offers binary, octal, hex and real-time display
- 64 X 16 bits memory, plus separate 64 X 16 bits compare memory
- Three clock qualifiers
- "Store Trig" provides quick and convenient paging through data stream
- Comprehensive diagnostic routines
- Trigger extension facilities

For more information contact your local Philips office or write to: Philips Industries
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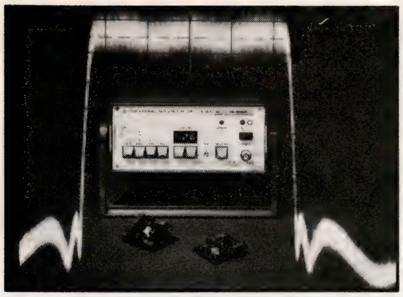
CIRCLE 155

Scope range extends tp 30 MHz

A dual-trace oscilloscope, CS-1577, catches high-frequency, fast transient pulses within an operational range of dc to 30 MHz. Vertical sensitivity is 2 mV/division. Sweep times range from 0.1 μs to 0.5 μs/division. Monitoring of the leading edges of fast risetime pulses is simplified by the inclusion of signal delay in the vertical amplifier. Features include automatic synchronization, a single-sweep facility for observation of non-recurrent events and an "auto free-run" mode, which enables the display of a trace in the absence of an input signal. The oscilloscope is made by Trio of Japan.

House of Instruments, 34/36 High St., Saffron Walden, Essex CB10 1EP, England. (0799) 22612. Telex: 81653. **CIRCLE 508**

Noise source tests system performance



A noise source, the SUF 2, produces a wide spectrum of noise with equal energy per unit bandwidth over a range of 20 Hz to 50 MHz. Output voltage is 1 V rms into a 75-Ω load. A choice of four-noise bandwidths allow measurements at audio frequency, FDM carrier frequency and video frequency. Level can be set in 1-dB steps over a range of 0 to −100 dB with the 110 kHz or 6-MHz bandwidths selected. Level is set over a 0 to −80 dB range with the 50 MHz range selected. Options include "pink" noise, "triangular" noise and "sound-program" noise.

Rohde & Schwarz GmbH, Muhldorfstr. 15, Postfach 80 14 69. D-8000, Munich 80, West Germany. (089) 41292625. Telex: 523703 **CIRCLE 509**

Digital controller works as μC slave

An industrial digital controller, the Intel iSBC 941, operates as a slave to a microcomputer. The device processes most digital I/O signals found in industrial control systems and frees a master microcomputer from many routine tasks. Typical applications include switch sensing, motor-speed control, stepper-motor applications and serial communications. The slave controller senses a change of state and can count and generate pulses, as well as measure time periods and frequencies. Nine preprogrammed primary functions can be requested by the master microcomputer. The device is housed in a DIP and requires a single 5-V dc supply.

GEC Semiconductors, East Lane, Wembley, Middlesex HA9 7PP, England. (01904) 9303. Telex: 28817.

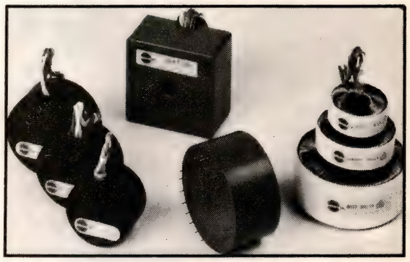
CIRCLE 510

Test set checks transmitters to 520 MHz

A transmitter test set, TTS520, part of a system controlled by a desktop computer, monitors the performance of units with outputs of 100 W. The transmitter test set joins a synthesized signal generator (Model SSG520BD) and a suitable controller, through an IEEE-488 interface module (SGIB-B) to form a composite system. TTS520 incorporates an rf counter, an automatic modulation meter, a directional rf power meter, an audio-frequency voltmeter and synthesizer, a distortion analyzer, an audio-frequency counter, weighting filters and an rf-power load/attenuator. Among the measurements the system can handle are transmitter frequency, power and modulation level, sensitivity, bandwidth, distortion and frequency. Also, transmitter continuous-tone modulation checks and measurement of antenna efficiency can be carried out.

Franell Instruments Ltd., Sandbeck Way, Wetherby LS22 4DH, Yorkshire, England. (0937) 63541. **CIRCLE 511**

Toroidal transformers give high power



Series 6000 toroidal transformers include 52 different types in nine standard power ratings between 15 and 500 VA. Primary voltage is 220 V ac. Because of their design, the transformers offer low weight, high power and extremely low magnetic interference fields. The parts can be mounted by use of a centering washer or, on the 30 to 120-VA sizes, they can be potted in a macrolon housing. Maximum height ranges from 31 mm on the 15-VA sizes to 62 mm on the 500-VA models. Outside diameter varies from 60 to 115 mm.

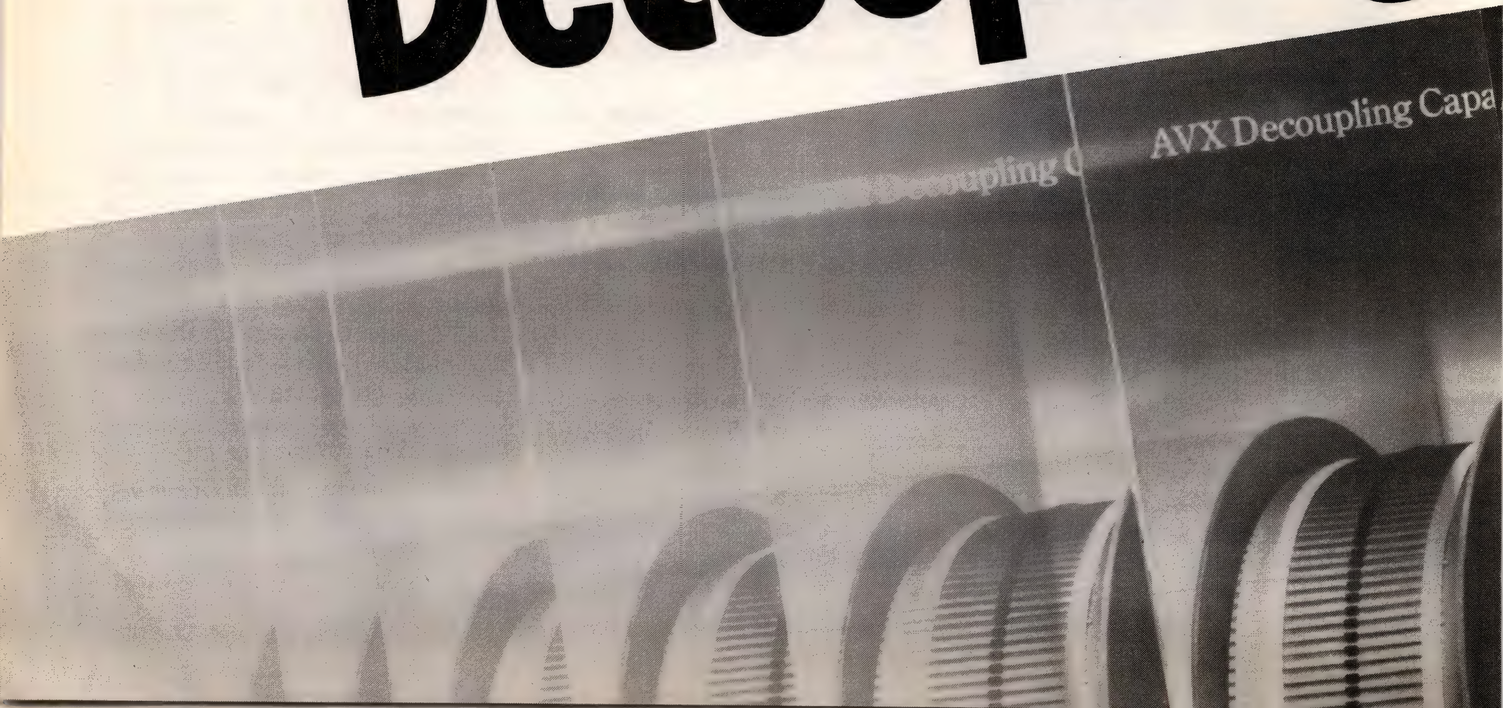
Talema Elecktronik GmbH, Bahnhofplatz 20, Postfach 31, 8034 Germering, West Germany. 089/84 30 33-36. Telex: 05 21 30 60.

CIRCLE 512

Choose any of these multilayer ceramic parts and we promise immediate despatch.

	CAPACITANCE (μF)							
Range	'Skycap' Dipped Radial					Moulded Axial		'DIPGuard' Dual-in-Line
STYLE	SR15	SR20	SR21	SR30	SR40	MA10	MA20	MDO1
X7R 50V (Suitable for 63V) ±20% Tol.	0.001 0.01	0.022 0.047 0.1	0.022 0.047 0.1	0.22 0.33 0.47	1.0	0.001 0.01	0.022 0.047	0.001 0.01 0.022 0.047 0.1
Z5U 50V (Suitable for 63V) −20+80% Tol.	0.01	0.022 0.047 0.1	0.022 0.047 0.1 0.22	0.33 0.47 1.0		0.01 0.022 0.047	0.1	0.01 0.022 0.047 0.1

Decoupling



Good news if you use decoupling capacitors in microprocessor, memory and other electronic circuit designs. Now you can get more than 40 of the most popular multilayer ceramic types despatched to you immediately on receipt of your order.

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AVX Ceramics GmbH, Feuerbachstr. 27, 8800 Ansbach. Tel: 0981/5695. Telex: 61760.

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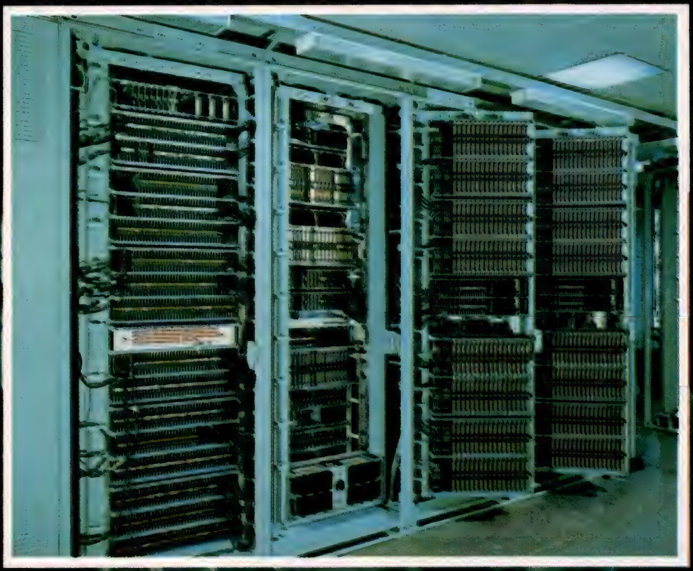
CIRCLE 156

We know how



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which uses time division
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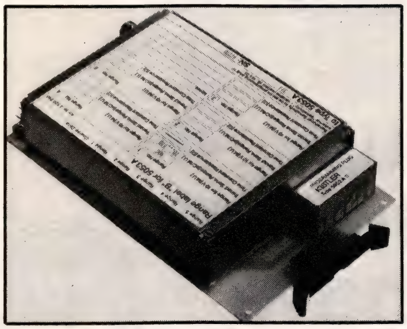
CIRCLE 157

Baked wires boost transformer strength

The short-circuit strength of power transformer windings is increased through the use of a baked varnish layer. The epoxy-based layer, applied over the insulating enamel, allows the elements of the twisted conductor winding to adhere to each other. During drying, the baked varnish hardens and binds the twisted conductors so that they cannot be shifted toward each other by short-circuit currents. Baked-varnish twisted conductors are available in two versions: single copper-conductor yield points of 80 to 140 N/mm^2 and 140 to 200 N/mm^2.

Felten & Guilleaume Carlswerk AG, Winding Conductor Div., Korbacher Strasse 4, D-3548 Arolsen, Federal Republic of Germany, (0221) 676 (1). Telex: 08873261 fug d. **CIRCLE 513**

Charge amp adapts to varied measuring jobs



A charge amplifier, used with piezoelectric pressure and force transducers, makes dynamic and quasistatic measurements. Type 5053 is assembled on a Europa PC board and consists of individual plug-in modules, permitting it to be adapted to a variety of measuring duties. The amplifier module comes in two versions: one with a MOSFET input stage for minimum drift with quasistatic measurements and a second version with a JFET input stage for high overload security. Up to five different range modules can be selected via an external electrical signal.

Kistler Instrument AG, Postfach 304, CH-Winterthur, Switzerland. (052) 25 2821. **CIRCLE 514**

Indicator freezes max/min reading

A process indicator, Type 107, displays maximum or minimum peak readings of any industrial parameter. The indicator also provides continuous measurement on any of 19 programmed ranges stored in its own microcomputer. A variety of thermocouple ranges are offered with automatic cold-junction compensation.

Control & Readout, Woods Way, Goring-by-Sea, Worthing, West Sussex BN12 4TH, England. (0903) 502599. Telex: 877169.

CIRCLE 515

Electronic Design INTERNATIONAL

reaching an international circulation of nearly 20,000 subscribers including Western European circulation of 16,192

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Free Catalog! Features tool kits, tool cases and test equipment, plus a selection of hard-to-find precision tools.

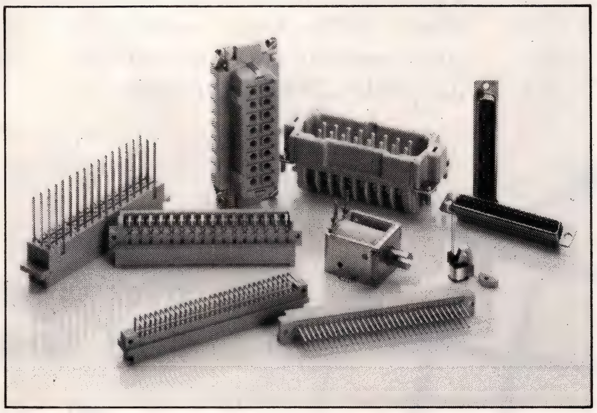
JENSEN TOOLS INC.
1230 S. Priest Dr. Tempe, AZ. 85281 U.S.A.

CIRCLE 158

Icarus – Or: the nose-dive we could have prevented.

His basic concept was no worse than that of the Wright brothers, Dornier or de Havilland. But his downfall was a component – beeswax. The reliability of this component failed when subjected to extreme operational conditions.

And the absolute reliability of even the smallest, seemingly most insignificant components is an essential today too in the age of large-scale series production.



Harting produces electrical components. Its wide range of Series Gds A connectors as per DIN 41612, VG 95324, IEC 130-14 and BS 9525, from heavy-duty connectors through to solenoids, offers you just this absolute reliability and security. Whether your production is measured in tens or in tens of thousands.

Specifically to achieve this standard of reliability we have invested a great deal in production technology, automatic production controls and tooling. For these are the indispensable pre-conditions for meeting today's high demands on product quality. Continuous mathematical-statistical monitoring guarantees the AQL value you demand for your systems and equipment. This not only saves you a lot of inspection costs in your receiving department but also a lot of trouble that hold-ups in your production would cause you.

But do not let this stop you making random checks – after all, we are pleased too when you find Harting quality confirmed on every test you make. For then, in company with many leading international producers and users of electronic equipment and systems, you too will find that.

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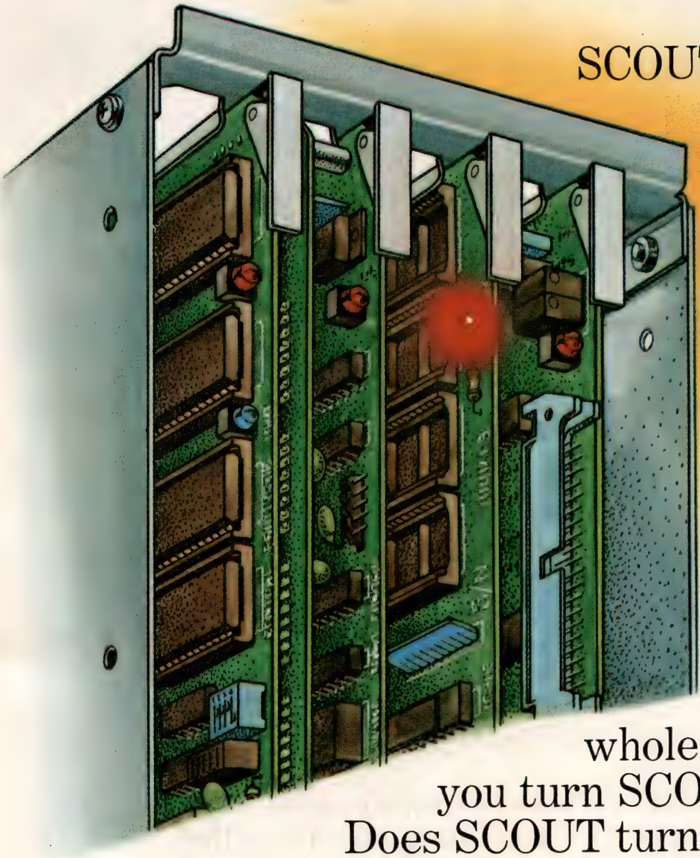
WÄCHTER BREMEN

CIRCLE 159

Speak SCOUT, speak.



SCOUT™ is a smart minicomputer. He can tell you when one of his boards is bad. Good SCOUT!

How does SCOUT do this? SCOUT has ISOLITE.™ Do you see the red light? It means ISOLITE is testing the board. If the light stays on, the board is bad. Bad boards don't get to play anymore. They get replaced with a spare 6.25″ x 8.3″ card in about three minutes.

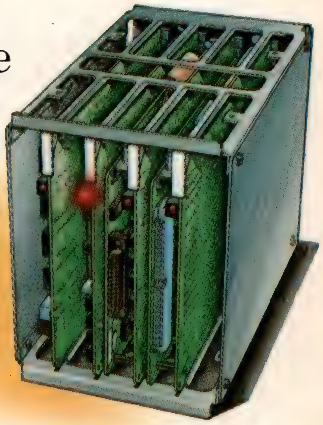
Isn't ISOLITE neat? It can even test your whole system every time you turn SCOUT on.

Does SCOUT turn you on?

Think what three-minute maintenance could do for your bottom line. Think what it could do for your product line. Everyone will love your products. You will grow very rich.

You will save up front, too. SCOUT starts at less than $1K for a 16-bit CPU, I/O, 32K Byte RAM and card cage. So, SCOUT also speaks to value.

Speak SCOUT, speak.



A Plug for SCOUT.

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Every bit of the 16-bit performance you need, plus incredible operating economy. It's all in our how-to-save-on-maintenance primer, *A Plug for SCOUT.* Get your free copy with this coupon and a business card. Or, for immediate information, call 714/833-8830, Ext. 455.

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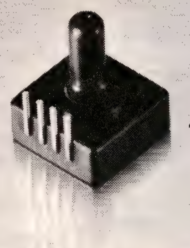
CIRCLE 32

One reason to choose this new pressure transducer is that it's affordable.

The other reason is very small.



Actual size

For years, two things kept many design engineers from using pressure transducers. Cost and size.

So MICRO SWITCH designed the 130PC series. Miniature, solid state pressure transducers priced so they can even be used in applications they weren't practical in before.

In some applications, like a mini weather balloon that uses the 130PC to measure barometric pressure, it's affordable enough to use only once.

And because it has a high degree of accuracy (repeatability is ±0.15% of full scale output) as well as a low price, the 130PC is being used in home blood pressure monitors.

Using laser-trimmed thick-film resistors on 135PC versions makes one transducer just as accurate as the next. And the 136PC is the only miniature transducer that uses a thick-film thermistor to compensate for temperature changes between 0°C and 50°C.

The 130PC series, gage or absolute, is available in 0-5, 0-15, and 0-30 psi ranges. Just like our 120PC series, which also has differential sensing capability, and our fully signal-conditioned 140PC series, which also has a 0-1 psi version.

Now that there's an affordable miniature pressure transducer, find out more about it. For details and the location of our sales offices and distributors around the world, write MICRO SWITCH, The Sensor Consultants, Freeport, Illinois 61032. Or call 815-235-6600.

MICRO SWITCH
a Honeywell Division

CIRCLE 33 FOR DATA

Moving high-speed digital signals from point to point in logic circuits requires interconnecting techniques that allow impedance matching and crosstalk control.

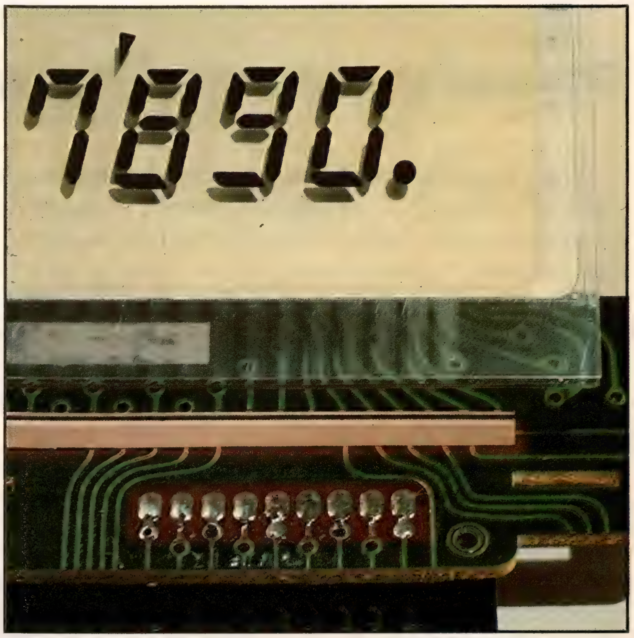
Challenge: interconnections for rising data speeds

With pressure to increase digital-data speeds unrelenting, design engineers constantly find themselves facing two major problems: designing the relatively short interconnections within circuit boards, and designing longer interconnections between boards, boxes and racks. In both cases, the logic signals must be coupled with minimum deterioration and crosstalk.

To solve the PC-board problem, advanced-semiconductor manufacturers say pack as much circuitry as possible onto large monolithic semiconductor chips (VLSIs). This will shorten distances and thus delay times between circuit components. Indeed, this approach apparently eliminates the need for much of the intraboard interconnection otherwise required between LSIs, MSIs and other logic chips needed in a typical digital circuit. (A major report on VLSI technology is included in ELECTRONIC DESIGN's Semiconductor Technology issue, June 7, 1980, p. 63.)

Morris Grossman, Packaging & Power Editor

Courtesy of AMP, Inc.



Courtesy of Conductive Rubber Technology

But after all the circuits have been crammed onto a single chip, the new VLSI chips still need to be interconnected on circuit boards, and the boards interconnected into a system. Furthermore, no matter how many functions are put onto single chips, the pressure remains to fill the boards with chips, and then fill the system cabinets with boards. Minicomputers may be replaced by smaller microcomputers, but then the micro units grow to mini sizes—offering 16-bit and then 32-bit word lengths with millions of bits of memory.

In addition, developing a VLSI is expensive; therefore, either the application must provide a market for high production volume to spread the development cost, or the application must be important enough to justify a high cost per chip. When neither condition applies, but the need for modernizing and upgrading to a high-speed-data capability does, logic modules such as the ECL series can solve the problem. With ECL, however, the familiar interconnection problems—ringing reflections and crosstalk—can become particularly acute.

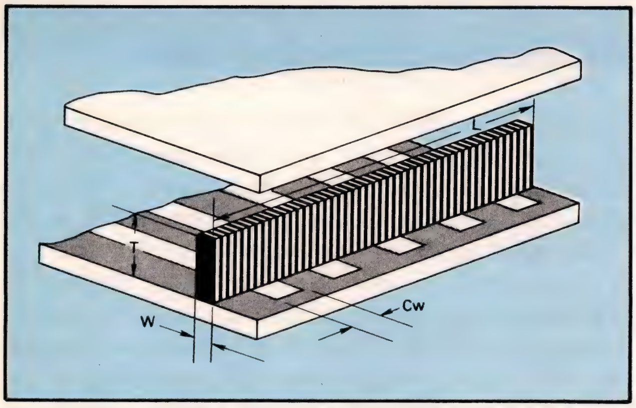
Trouble is, high data speeds require specially designed signal paths. A design article by Jim Fetterolf of AMP, Inc. (p. 95) covers the basics of high-data-speed, transmission-line impedance-matching and crosstalk problems, and how interconnect impedances can be controlled with microstrip, twisted-pair and flat-cable connecting techniques.

Another design article (p. 113), by John A. Pierce and Ed Malitz of Formation, Inc. and Mike Wilson of Automated Systems, Inc., describes how high-speed ECL circuit-board design can be automated to follow these transmission-line concepts and avoid the problems of impedance discontinuities, reflections and crosstalk in such special equipment as high-speed computers.

But whether dealing with high or low-speed signals, the signals eventually must go through connectors and switches. Unconventional conductive-elastomer materials offer effective and economical solutions in many applications. Designers wishing to get involved, however, should get to know conductive elastomer materials better and avoid potential pitfalls by reading the design article by Harry Stern of Conductive Rubber Technology, "Conductive-Elastomer Applications Abound" (p. 105).

Conductive elastomers—versatile fill-ins

When used as connectors, conductive elastomers could offer many advantages, especially in applications such as connecting liquid-crystal displays and the emerging generation of chip carriers to PC boards. An elastomeric connector consists of alternate layers of conducting and insulating elastomeric rubberlike material, generally a silicone (Fig. 1). The elastomer is basically an insulator, but when filled with a conducting material like carbon or silver (Tecknit, Cranford, NJ, calls its versions Zebras), it will conduct electricity: Carbon-filled units provide relatively high resistances of 10 to 1200 Ω—silver-filled units considerably less.



1. Alternate layers of conductive and insulating elastomeric materials, whose pitch (conductor-to-conductor spacing) is finer than the spacing between the contacts to be mated, make excellent connectors between stacked circuit boards.

For example, in Silver Stax, a silver-filled conductive-elastomer connector made by Hulltronics Inc. (Hatboro, PA), contact resistance decreases to 40 to 60 mΩ. It comes in 1, 2 and 3-in.-long strips. With time, the silver powder or flakes that fill the conductive silicone-rubber layers between the insulating layers (each layer is 2 mm thick) tend to become packed and contact resistance drops even lower—to about 10 mΩ for a 50-mm-square pad.

Japan's Shin-Etsu Polymer Co. offers the silver-filled HL Series (handled in the U.S. by Conductive Rubber Technology, Santa Barbara, CA). Silver powder in a sponge-rubber base provides contact resistances less than 1 Ω, with unusually low compression forces—just 1 lb/in. is needed for 10% compression. In 7-in. lengths, the strips provide gas-tight contacts that protect the silver from tarnishing. Also, the special formulation prevents silver migration, a serious problem plaguing most silver-filled elastomers.

In another form, high conductivity (25 to 50 mΩ) is provided by equally spaced, imbedded thin wires that are insulated from each other. (Tecknit offers such a product called Conmet, with up to 40 wires/in. interspersed in 0.03-in.-wide silicone strips.)

But conductive elastomers also can be used as switches (Fig. 2). When in sheet form, the material becomes particularly suitable for making low-cost multiswitch keyboard pads. Companies such as Chomerics (Woburn, MA) and Flex-Key (Gloucester, MA) specialize in such membrane keyboards; Tecknit makes switch contacts (ESCON) and Conductive Rubber Technology also includes switches among its many other conductive-elastomer products.

2. A major application for conductive elastomers is in low-cost switches, such as this keypad offered by Conductive Rubber Technology.

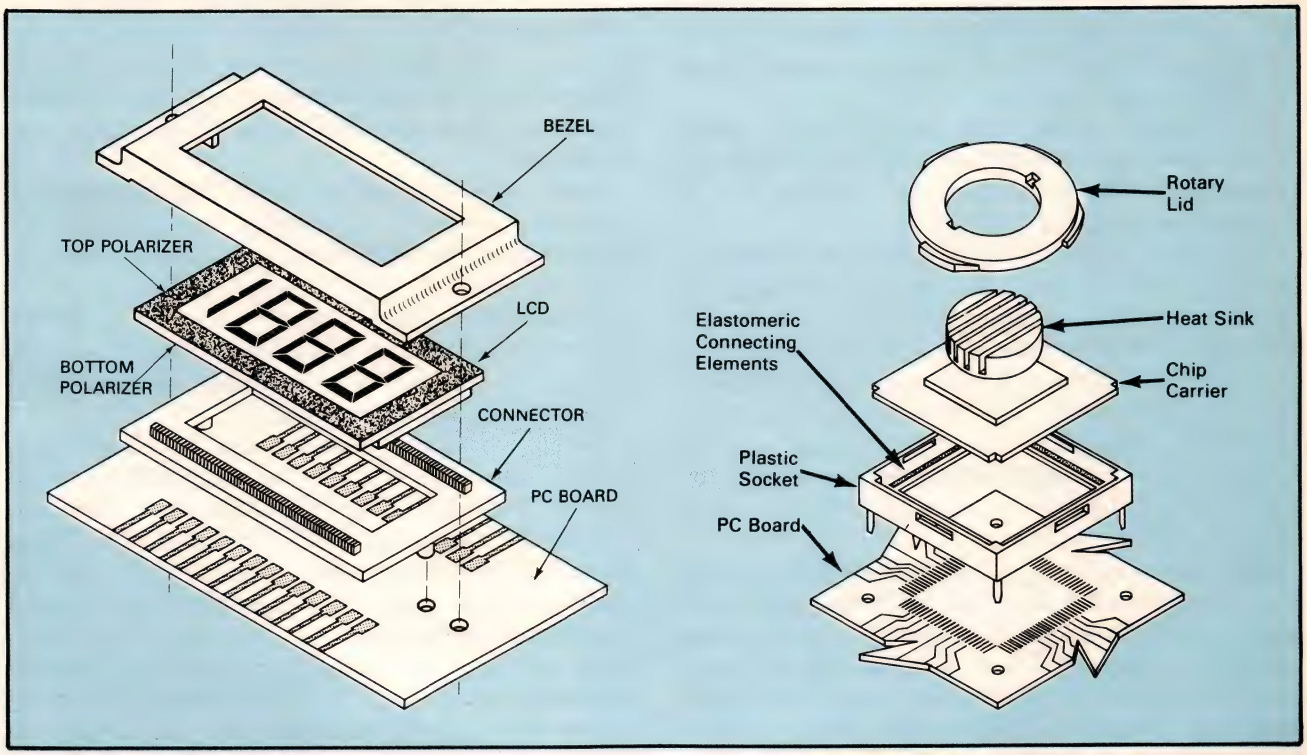
Not only that, but conductive elastomers can be made into excellent conductive gaskets and EMI shields (Electronic Design, April 26, 1979, p. 87), a specialty of the Metex Corp. (Durham, NJ).

In both gasket and connector applications, the elastomer material is sandwiched between rigid mating units, which allows the material's soft compliance to eliminate any problems associated with differences in thermal-coefficient expansion between the mating parts. Also, since no soldering or mating/unmating forces are involved, densely packaged parts and subassemblies may be assembled and disassembled rapidly without the danger of damage to delicate components such as LCDs, chip carriers and small circuit cards.

To top it off, electrical contacting surfaces on the mating parts do not need any special treatment. Nor, in general, do they need to be made of special materials (for connectors, however, gold—a very thin 10-μin. flash is enough—is preferred for high-reliability applications). The rubberlike elastomeric material makes contact with mating surfaces without abrasion (thus, the gold plating can be very thin). Mating surfaces for most ordinary applications can be made of nickel, stainless steel, tin, conductive plastics and many other conductive materials. In addition, the materials's compliance can absorb mechanical vibration and shocks, thus protecting delicate parts in devices like clocks, watches and tachometers.

But the prime application areas for conductive elastomers are connecting LCDs (Fig. 3a) or the coming chip carriers to PC boards. In the former application area, the material's low-force requirements allow using long lengths, up to 8 in. of the elastomer, which eliminates the possibility of bowing the mating board.

However, the latter application area looks especially promising (see Fig. 3b and Electronic Design, March 15, 1979, p. 36).



3. Connectors for LCDs (left) and the new square chip carriers (right), as made by Tecknit, come in a variety of styles and sizes for devices of almost every size.

Integrated-circuit manufacturers, having spent hundreds of millions of dollars over the years to squeeze thousands of circuits onto tiny silicon chips, now face the prospect of spending additional millions to develop chip carriers and lead frames that enlarge the chip-contact configurations. This way, the circuits can be connected to the outside world. These contacts and their leads can occupy as much room as the circuits, or even more.

Elastomeric connectors, however, could be designed eventually to eliminate most of this contact space, and save the real estate so painstakingly and expensively won by the IC makers. What's more, conductive-elastomer connectors would be especially suitable for connecting vertically stacked circuits and components. Such piggybacking of chip carriers or VLSI substrates can further increase the circuit density, and still allow quick disassembly for access to all parts in the stack.

Elastomeric connectors have been applied by Tecknit to several compact assemblies, such as a tachometer and an electronic chronograph.

Data speed puts convenience second

Elastomeric connectors, or any other kind, are designed primarily to make assembly and disassembly of parts and subassemblies convenient. But when signal bandwidths rise to the region of 350 MHz, which corresponds to data-signal rise times of about 1 ns, transporting the signals from point to point with a specified fidelity imposes special requirements on connectors that replace convenience as a primary consideration.

In fact, the very wiring between and within components becomes a crucial issue, and particularly when emitter-coupled logic—probably the fastest class of logic circuits available—is used. Unfortunately, ECL devices are very difficult to represent accurately with passive, linear equivalent circuits, so ballpark figures are the best that can be expected (see "Wiring for High-Speed Logic").

Nevertheless, wiring rules for ECL can be established based upon the well established principles of transmission-line techniques, and boards can be successfully designed and wired.

Trouble is, applying the many rules—especially keeping track and documenting many wiring paths for any reasonably complex system—is a major job best done with a computer. Automated Systems (El Segundo, CA), for one, has joined with Formation, Inc. (Mount Laurel, NJ) to develop a program (PRANCE TTL/ECL) for ECL "wiring" on PC boards. Other companies supply a program on punched cards to guide an automatic Gardner-Denver Wire-Wrap machine.

Although wire-wrappable ECL boards (especially those designed with microstrip techniques) may have greater impedance variations than PC boards, Augat (Attleboro, MA), Hybricon (Littleton, MA), Garry Manufacturing (New Brunswick, NJ) and Electronic Moulding Corp. (Woonsocket, RI), among others, claim that these variations can be kept well within acceptable limits when the proper rules of lead-length limiting, net terminating and wire routing are followed. At the same time, the boards must have not only built-in ground and reference planes that cover most of the board area but also strategically located mounting provisions for terminating and pull-down resistors.

A major advantage of wire-wrapped boards is that they can be updated readily in the field. Interconnections are easily rerouted or changed: Merely unwrap unwanted wires and place new ones between proper pins with a simple hand tool. PC boards, on the other hand, might have to be discarded for other than very minor changes.

Density is another wire-wrapping advantage. A PC board would need as many as 15 layers to equal the wiring density of a typical wire-wrappable board. Not only that, but multilayered boards need long lead times to design and are not easily changed once fabricated.

Once wire routing has been established (by a computer program, preferably), many wire-wrapping services (including Gardner-Denver's) are available to wire boards automatically (or semiautomatically). Data Con (Woburn, MA), Garry Manufacturing and Excel Products (New Brunswick, NJ) offer such services, including standard wire-route design and documentation.

When wiring impedance must be closely controlled, other wiring methods, such as Stitch Wire (by the Multi Link Div. of Odetics, Inc., Anaheim, CA) or Multiwire (by the Kollmorgen Corp., Glen Cove, NY) claim even better results. Wire dressing and routing generally can be held closer to the board and lengths better regulated than with wire wrapping. All points common to a single net can be connected by a single, unbroken wire (thus presenting fewer discontinuities), and any degree of desired automation is available. Unlike wire wrapping, however, these special wiring systems, and the

Wiring for high-speed logic

To help establish wiring rules for ECL logic, the design engineer can turn to a linear equivalent circuit, even though ECL circuits are far from linear. The top figure shows a suggested approximation for an ECL-gate output driving another ECL-gate input. Depending on the ECL family, the gate's incremental output resistance, R_o, can be between 5 and 20 Ω and the gate's input resistance, R_i, about 50 kΩ (worst case at logic-level ONE). Capacitance, C, results mostly from components, connectors and wiring, and is generally about 8 to 10 pF per gate load. And L, the series inductance of the signal path (wiring, connector pins, etc.), is roughly 5 to 10 nH/in. Trouble is, these values can vary greatly depending on the dress, length and gauge of the wiring, and the material of the circuit board.

A sharp rise time from a gate output of 2 ns (or less) will excite the LC circuit to overshoot and generate ringing as shown. Long lead lengths (therefore high inductance) and high stray capacitance aggravate overshoot. Overshoot is reduced most effectively by good wiring techniques—using short leads, running them close to the ground plane and using flat conductors—all of which reduce inductance. (The level of the stray capacitance, however, is difficult to reduce. Indeed, running leads close to ground increases capacitance.) In addition, a resistor, R_d (10 to 30 Ω), in series with a gate input lead, can help dampen overshoot.

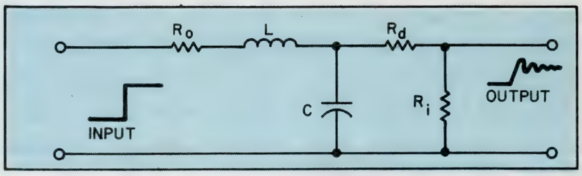
All that's fine, except that the suggested equivalent circuit leaves out a very important part of the story: the need for impedance matching. As the signal-path length from source to load starts to represent a substantial portion of a wavelength (more than 10%), signal reflections from the interfaces with the path can cause as much (or more) trouble as ringing—unless the signal-path characteristic impedance matches the rest of the circuit parts (input and load).

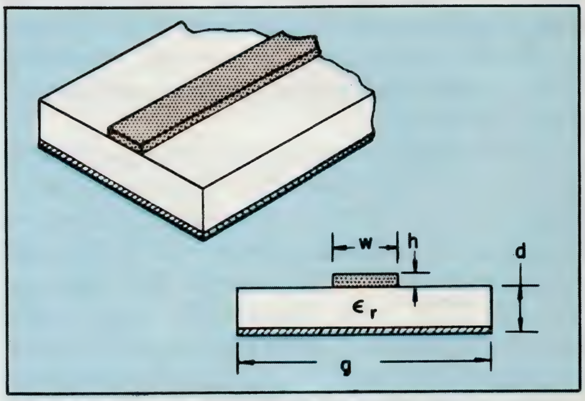
The impedance of a wire-over-ground interconnection can be approximated by the following equation:

$$Z_o = \sqrt{L/C} = \frac{138}{\sqrt{\epsilon_r}} \log_{10}\left(\frac{4D}{d}\right),$$

where D is the distance of the wire from the ground plane, d is the wire's diameter and ϵ_r is the dielectric constant between wire and ground.

To keep Z_o low—in the vicinity of 50 to 100 Ω—D should be small. In other words, the wire should be close to the ground (which reduces L and increases C). Fortunately, Z_o is not very sensitive to changes in the D/d ratio because of the logarithm in the equation; therefore, methods like wire wrapping do not introduce serious discontinuities as D changes.





A typical 100-Ω line-over-ground configuration (D/d ≅ 1.3) in air has about 9-nH/in. inductance, but only about 0.8-pF/in. capacitance—low when compared to the previously mentioned total of 8 to 10 pF/in. This explains why impedance and delays are minimally affected by changes in C and depend mostly on the L of the wiring.

Of all the wiring methods, microstrip wiring assures not only close proximity of the conductors to ground but also a uniform spacing from ground—and therefore constant impedance. Microstrip is part of a class of transmission-line technology first introduced for rf microwave circuits. The configuration in the bottom figure is an outgrowth of coaxial geometry, but implemented in a planar fashion on PC boards as well as in some types of flat cables.

The conductor's width, and its thickness, h, is small relative to the ground-plane width, g. Also, the dielectric thickness, d, is less than one-quarter the wavelength of the signal (dielectric constant is ϵ_r). Except for a small leakage flux, the characteristic impedance would be simply

$$\begin{aligned} Z_o &= 377\ (h/w)/\sqrt{\epsilon_r} \\ &= T_d/C, \end{aligned}$$

where C is the strip's capacitance to ground in farads per unit length, and T_d is the dielectric's propagation delay in seconds.

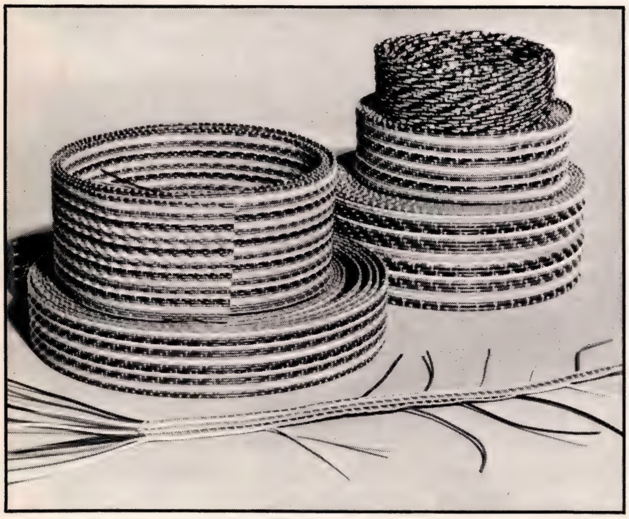
equipment and boards to implement them, are proprietary and not as widely available.

Although such above-the-ground-plane wiring methods can help keep overshoot, reflections and crosstalk problems under control, the ultimate impedance-controlled interconnection is the coaxial connection. Unfortunately, the cylindrical geometry of a coaxial interconnection is not very compatible with, or convenient for, wiring on the planar geometry of a PC board.

Theoretically, this cylindrical geometry can be replaced by a sandwich consisting of a flat conductor between two infinite ground planes, called stripline. When the top ground plane is removed, microstrip geometry results, which is perfectly compatible with PC-board technology.

Despite an apparently radically different physical arrangement, the desirable transverse electromagnetic mode (TEM) of the coaxial geometry is still retained to a great extent in microstrip. The path through air of some of the electric flux does not disturb the TEM mode substantially. As a result, high-speed data signals can be handled with fidelity. But designers must pay close attention to impedance matching and to the parallelism rules for keeping crosstalk down.

Unfortunately, microstrip—or other etched-copper PC-board wiring—is not as readily adaptable to changes and revision as the above-the-ground-plane methods, especially when circuit complexity requires a multilayered PC configuration. Multilayered boards require long-lead times and become economical mostly for large-quantity production. The rival wiring techniques, especially when automated, can handle both small and large quantities economically.



Woven cable, a very versatile way of providing a controlled-impedance interconnection, is exemplified by these Woven Electronics' flat-cable configurations.

Flat/ribbon cable tightens impedance control

However, the planar geometry of the microstrip does carry over into cable in the form of flat, or ribbon, cable—and with it goes the advantages of close impedance control and a good measure of crosstalk reduction.

Although many engineers use the terms "flat" and "ribbon" interchangeably, Spectra-Strip (Garden Grove, CA) and Kel Am (Eldon, MO) apply "flat" where the conductors are flat (or rectangular in cross-section) and "ribbon" when they are round (solid or stranded).

Most ribbon cables have the wires, generally 28-AWG stranded (seven strands), spaced on 0.05-in. centers to conform to most available flat-cable connectors. Although 24 AWG also is readily available, larger conductors such as 20 or 18 AWG require connector-design changes to conform to their wider wire spacing.

Many companies, including Brand Rex (Willimantic, CT), Spectra-Strip, Belden (Geneva, IL), Tenesolite (Tarrytown, NY) and W.L. Gore & Associates (Flagstaff, AZ) make flat cable, but with widely differing choices in insulating material, wire stranding, electrical and mechanical tolerances, and cost. Nevertheless, some "standardization" is adhered to, such as the 0.05-in. wire centers and specific characteristic impedances in the 95 to 120-Ω range. Standarized wire spacing enables automated mass terminations with insulation-displacement connectors (IDCs). Indeed, many companies have introduced compatible flat-cable/connector systems for mass-terminating.

For example, TRW Cinch (Elk Grove, IL) offers a 28-AWG stranded or solid-wire cable with 0.05-in.-center spacing and seven sizes of connector receptacles with optional strain reliefs. G.C. Electronics (Rockford, IL), Spectra-Strip, Socapex (Canoga Park, CA) and Alpha/CW (Warminster, PA) also supply 28-AWG ribbon/connector systems.

The planar geometry is exemplified also by woven cable made with the same process used to weave textile ribbon. However, woven cable allows transposing the wires (as with twisted pairs) to help reduce crosstalk. In addition, the weaving process allows a lot of flexibility: impedance control, strain reliefs and tack lines; also, many mixes of wire sizes may be run. Woven Electronics (Maudlin, SC) and Geyer Systems (Timonium, MD) both offer extensive varieties of cable combinations.□

MEASUREMENT COMPUTATION news

product advances from Hewlett-Packard

INTERNATIONAL edition JUNE 1980

HP's powerful new graphics computation system provides fast and easy comprehension of data with brilliantly colored displays. A built-in light pen allows the user to interactively pick, move and draw directly on the CRT.

HP-IB

Create brilliant, graphic interpretation of data with ease and speed

HP's newly introduced 9800 Series 45C Computer System features powerful graphics computation capable of displaying results in up to 4,913 crisp, clear colors.

Based on HP's proven 9800/45 Series Computers, the 9800/45C is an easy-to-use graphics computer system that sits on your desk. Built-in, color graphics CRT display, light pen, operating system, up to 449K-byte user read/write memory,

(continued on third page)

IN THIS ISSUE

- New, non-contact distance meter
- Automatic performance in versatile, low cost counter

Now you can create and manage *technical* data bases on the HP 9800/45 computer—with HP's award-winning IMAGE data base management

Hewlett-Packard's new data base management and data communications capabilities can put your technical data to work!

HP's new 9800 System 45 Data Base Management System gives you an HP IMAGE-based software/firmware package that allows you to transform your raw technical data into a useable, beneficial resource. Now, for the first time, you can interactively design, define, access and manage a data base right at your desk.

The HP 9800 System 45 version of IMAGE (called IMAGE/45) consists of two plug-in Read Only Memories (ROMs) for the HP 9800 System 45 Computer. These ROMS contain the HP Enhanced BASIC statements needed to define, manipulate and maintain your data base.

Reduced programming time

To facilitate "ad hoc" or unanticipated data base inquiries, this package features QUERY/45, a special data base access software pack that reduces programming time and effort by providing highly interactive data base manipulation routines. By simply typing in English-like commands, you can read, enter, delete or modify data—all without writing application programs.

The 9800 System 45 DBMS also includes a helpful Data Base Design Kit that takes you step-by-step from the definition of your data handling problem to the full implementation of a DBM solution. The 9800 System 45 DBMS doesn't just put your data on file . . . it puts it to work!

Desktop data communication

A new data communications capability for the HP 9800 System 35 and 45 Computers successfully bridges the gap between a small computer work center and a large host mainframe. The 9800 System 35/45 Data Communications package (firmware and software plus a new interface card) is designed specifically for flexibility and ease of use in both asynchronous and synchronous (RJE Bisynchronous) modes.

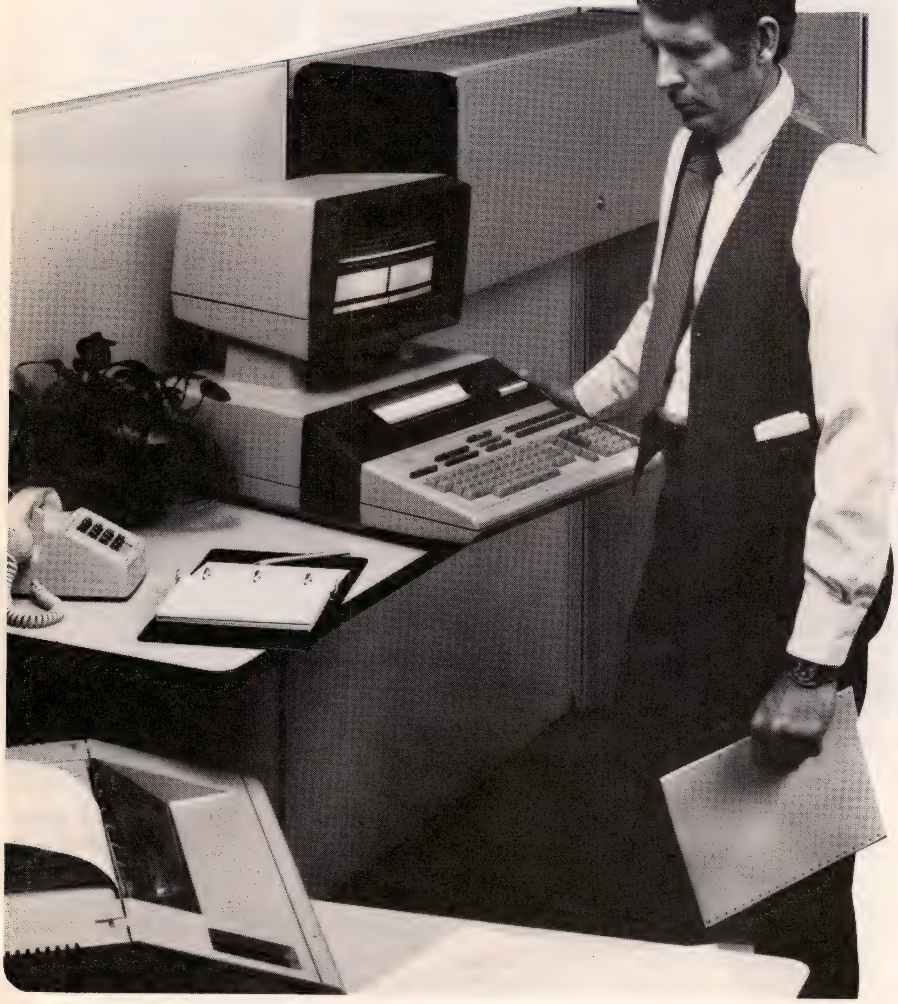
The asynchronous package, which is particularly attractive in time-sharing applications, features data transmission rates of up to 9600 bits/second, split speed operation, automatic parity checking, automatic modem control, auto answer and full-duplex line management.

The RJE Bisynchronous capability offers IBM 2780-3780 terminal emulation, transparent mode, short record truncation, blank compression, data transfer rates of up to 9600 bits/second and half- or full-duplex line management.

For complete details on how you can put these new capabilities on your desk (or on your HP 9800 Series Computer), check **A** *on the HP Reply Card.*

HP-IB

This new Data Base management capability for the 9800/System 45 means you can have a full-time, workhorse computer and a "brilliant", part-time terminal . . . all in the same instrument.



Get fast solutions to complex graphics computation problems

(continued from first page)

enhanced BASIC language, keyboard, mass storage and thermal line printer are all integrated into a single workstation that can help solve your problems in a convenient and uninterrupted fashion.

The 9800/45C brings eye-opening color and clarity to practically any application you choose. Designed primarily for the scientist and engineer, this new system can help create more effective data presentations, increase productivity and solve complex problems. Color can be used for faster data interpretation of mathematical relationships, to provide greater definition of detailed designs or add realism. The viewer will enjoy fast, easy comprehension of displays that, with color, can be more informative and memorable.

In addition to a high quality display with many color combinations, the 9800/45C also features HP Graphics Language which cuts programming time and effort. This built-in firmware provides 70 graphics statements that enable the user to get faster solutions to complex graphics-computation problems. The 9800/45C can provide three-dimensional representations in solid or wire-frame form. Statements such as POLYGON and RECTANGLE automatically draw the geometric figures. FILL parameter allows you to fill the insides of the figures with color without calculating points. This firmware also enables both alphanumeric and graphic rasters to be displayed simultaneously, making the user's graphics computation more convenient and interactive. And statements for use with the built-in light pen allow the user to interactively pick, move and draw directly on the CRT.

With all this built-in performance, the 9800/45C still remains friendly and easy to use. With the flick of a single switch, all the elements of this computer system begin working together to bring you quick solutions to your problems.

For more detailed information on the 9800/45C, call your local HP Sales Office or check ***B*** *on the HP Reply Card.*

Serial data analyzer adds new features for monitoring and simulating data networks

Hewlett-Packard's 1640B Serial Data Analyzer is a tool for troubleshooting data communications networks, through transparent monitoring of RS-232-C (V24) serial lines or simulation of network components. The menu-driven analyzer is programmed for a versatile measurement set and is easy use. New features have been added, based on field experience, extending the applications of the original analyzer and offering even more convenience for the operator. Retrofit field kits are available to add the new features to present 1640A Serial Data Analyzers.

These new features include two branching modes for simulation operation. The 1640A can transmit a first message repeatedly and then automatically send one of the two remaining messages based on a match between the response and the analyzer reply-condition parameters set by the user. The addition of the branching modes provides a much needed simulation capability for effective network testing.

A new memory bit shift can be used to shift either TX or RX data, bit by bit, to check for dropped bits, clock slips, locate unknown sync patterns and similar detailed tests. Also, any selected character in the list display is simultaneously decoded in binary, octal and hexadecimal, a handy prompt when editing text. Clock accuracy for Model 1640B is improved to ± 0.01%.

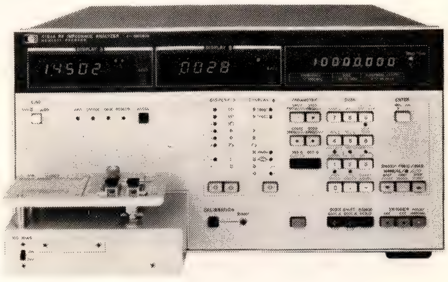
HP's model 1640B Serial Data Analyzer will help you move quickly from a symptom to the cause in troubleshooting computer networks which use RS-232-C (V24) serial data transmission.

Check ***C*** *on the HP Reply Card for more technical data.*

RF impedance analyzer measures 14 parameters over 1-1,000 MHz range with basic accuracy of <2%

This new Hewlett-Packard 4191A RF Impedance Analyzer measures 14 impedance parameters over a frequency range of 1 MHz to 1000 MHz with a basic accuracy of less than 2%. An internal frequency synthesizer, automatic calibration, automatic error correction and specially designed test fixtures make stable, accurate impedance measurements possible over a measurement range of 1 mΩ to 100 kΩ (1 μS to 50S).

In addition, the 4191A features an internal bipolar dc bias source (0 to±40 V), linear and log sweep capability of both frequency and bias, self-test and deviation measurements capability (Δ, Δ%) on all 14 parameters. These features make the 4191A RF Impedance Analyzer an excellent design and testing tool for high frequency evaluation of electronic materials, components and circuitry. Typical applications include high resolution crystal measurements, low loss measurements of an air capacitor, thin or thick film circuit analysis and PIN diode impedance measurements.



Designed for making high frequency evaluation of electronic materials, components and circuitry, this 4191A RF Impedance Analyzer provides high accuracy with 4½-digit resolution.

Check ***D*** *on the HP Reply Card for complete information.*

A complete audio measurement system all in one instrument

This new audio analyzer uses an internal microprocessor to control measuring sequences by turning **on** and **off** the audio source and by measuring and displaying the result.

A new audio analyzer which makes complicated audio measurements with a single keystroke is available now for audio test and transceiver test applications. HP's 8903A Audio Analyzer achieves this by a low distortion audio source with a highly flexible analyzer in one instrument which can measure DC volts, AC volts, distortion, signal to noise, SINAD, and audio frequency from 20 Hz to 100 kHz.

Using its powerful microprocessor-controller, the 8903A accomplishes tedious routines of complicated quantities like signal/noise. With a single keystroke, it controls and gates the audio source, then measures and computes the ratios of the resulting signals from the transceiver under test.

The audio source section provides 0.6 mV to 6V open circuit from 20 Hz to 100 kHz with frequencies and levels set by keyboard. Log sweeps can be programmed, as well as frequency increment changes, with single keys. Front panel frequency display resolution is 5 digits, while the amplitude display is 4 digits, giving plenty of resolution whether in linear or dB units.

The 8903A drives an X-Y recorder directly. Y-axis output is scaled to 0-10 V for the units selected by key, and measurements can be in absolute terms or dB and percent relative to a prior measurement or a key-entered number.

General audio testing

For general audio testing the 8903A can measure frequency response, swept distortion, hum and noise, gain, and power output. For AC level and distortion tests, a true RMS detector provides best accuracy. Distortion measurements can be made to typically less than 0.003% (−90 dB) between 20 Hz and 20 kHz. AC level accuracy is specified at ±0.5% from 20 Hz to 20 kHz.

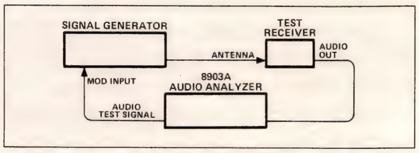
In transceiver test applications, the 8903A source can be used to modulate the test transmitter while the demodulated output of the companion 8901A Modulation Analyzer is measured for distortion and frequency response. An internal psophometric filter allows testing to CEPT recommendations. The counter measures squelch tones, while other filtering rejects squelch tones for the audio tests.

Since both SINAD (FM receivers) and signal-to-noise (AM receivers) test sequences involve noisy readouts, special digital smoothing takes place in the microprocessor to prevent "jumpy" displays and to deliver a digital reading that is known to be valid.

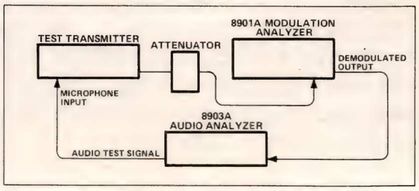
The analyzer section accepts signals from 1 mV to 1V at DC and 20 Hz to 100 kHz. In the automatic mode it autotunes to the input signal and autoranges to the distortion or level function range for best accuracy and resolution.

In addition, the 8903A is fully programmable under HP-IB control for use within automatic test systems.

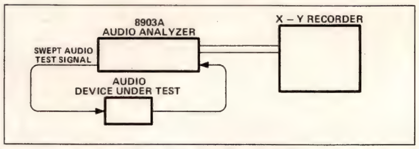
Check **E** *on the HP Reply Card for additional information*



Receiver Testing With the 8903A



Transmitter Testing With the 8903A



Swept Audio Testing With the 8903A

Cut the cost of data transmission

The new HP 37230A Short Haul Modem reduces the cost of limited distance data transmission by replacing a conventional modem. However, it retains many of the features of a conventional modem such as automatic equalization and a diagnostic test capability. Providing synchronous transmission of data at rates of 2.4, 4.8, 9.6, and 19.2kb/s, the 37230A is designed for half-duplex, full-duplex, and multi-drop operation over local circuits.

Automatic equalization in the 37230A compensates for variable characteristics of the telephone circuits. This optimizes the performance throughout the specified range and removes the need to perform any adjustments on the modem, thereby simplifying the installation.

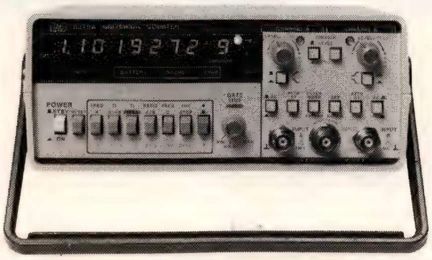
Diagnostic test features in the 37230A include local and remote digital loopback, local analog loopback, and a test pattern generator/error detector. These facilities are used for system testing and fault-finding without the need for any other test equipment.

The HP short haul modem is used over unloaded metallic circuits which can be either installed privately or leased from the telephone company. The modem operates half-duplex on 2-wire circuits, and half-duplex, full-duplex, and multi-drop on 4-wire circuits. Suitable circuits can normally be obtained from the telephone company but may be restricted to within one end office (exchange) area. The 37230A complies with the requirements of BSTR Pub 43401 for use on telco-supplied circuits in the USA; and Hewlett-Packard is applying for connection approval in other countries.

For other details, check **F** *on the HP Reply Card.*

Typically, the operating range of HP's 37230A Short Haul Modem can be from 4 miles over 26 AWG wire at 19.2kb/s up to 22 miles over 19 AWG wire at 2.4kb/s.

A counter with some new twists



HP's 5315A/B Universal Counters use a microprocessor and a new, HP-developed IC to bring you a remarkable set of measurement capabilities at a surprisingly low price.

At first glance, HP's 5315 Counter may seem like just another very capable universal counter. It measures frequency and period to 100 MHz (1 GHz optional), time interval with resolution of 100 ns single shot or 10 ps averaged, period average, frequency ratio, frequency burst, and totalizing. However, the 5315's circuit innovations and manufacturing design, using a microprocessor and the remarkable HP multiple register counter IC, make possible performance and versatility you'd expect to find only in a much more expensive instrument. For example:

- 7 digits of frequency resolution per second via the reciprocal measurement technique.
- continuously variable gate times.
- dual-mode input conditioning to optimize both frequency and time interval measurement.
- input filter, time interval delay and automatic resolution control for noisy inputs
- very low RFI/EMC for applications absolutely requiring electrical quietness.
- optional, built-in, sealed, lead-acid battery with protective and charging circuits.

Below 10 MHz, the 5315 uses the reciprocal taking frequency measurement technique which measures the input's period, but inverts the result to display frequency. This gives you up to 8 digits resolution for frequencies as low as 0.1 Hz, without using long gate times or phase-locked multipliers. Above 10 MHz, the 5315 automatically switches to the conventional cycle-counting technique, providing you with the highest resolution over the counter's entire range.

For full information, check **G** *on the HP Reply Card.*

New structural dynamics analyzer simplifies design of control systems and mechanical components

HP-IB

Optimized for the study of vibration and noise, HP's new 5423A Structural Dynamics Analyzer features broad measurement, post-processing and display capabilities. Easily studied problems include those involving modes of mechanical structure vibrations, control system design, and the monitoring and balancing of rotating machinery. Frequency range is DC to 25 kHz.

For structural analysis, an animated, mode shape display shows structural deformation at each resonant frequency. Display features include perspective, rotation, true three dimensions, selection of viewing direction/distance, "zoom" split-screen viewing and stop-motion.

A powerful waveform calculator enables mathematical computation of many useful functions which cannot be measured directly. For example, with just a few keystrokes it is possible to compute a control system's open loop frequency response from a closed loop measurement, yielding quick information about the system's gain and phase margins. A **Synthesis** key allows the frequency response of trial compensation networks to be calculated and displayed.

Other features include simple keystroke programming via an **Autosequence** capability, easy data annotation, data storage to a built-in digital tape cartridge, and fast plotting to a wide choice of HP-IB compatible digital plotters.

Obtain further information by checking **H** *on the HP Reply Card.*

Combining simple keyboard operation with extensive measurement and display capabilities, this new HP analyzer makes it easy to identify and solve difficult structural and control system problems.

HP designs a new, non-contact, distance meter for industrial control, tracking and monitoring

HP-IB

The 3850A is designed for industrial applications such as manufacturing processes where accurate and rapid measurement of distance is critical.

A new electronic distance measurement device for measuring and controlling the position of objects in industrial environments is now available from Hewlett-Packard. The 3850A Industrial Distance Meter makes accurate, non-contact distance measurements using an invisible infrared beam transmitted to a target that reflects the beam back to the instrument. By modulating the beam and comparing the phase relationship between returned energy and an internal reference, the 3850A accurately determines the distance between itself and the target. The instrument achieves a resolution of 1 mm (.040 in) over a range of 8 km (26,240 ft) in either manual or computer programmable modes.

Other automatic features include:

- non-contact distance measurement—updating 9 times per second
- determination of the elapsed time between distance measurements—providing velocity and acceleration data
- status information on the measurement system—enabling the user to monitor system conditions.

When coupled to the HP 9800/25S Computer, the system combines data with time information to determine position velocity and acceleration, providing a powerful feedback control system.

Check **I** *on the HP Reply Card for details.*

Hybrid RF designs easy to produce with two new HP transistors

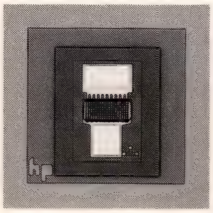
As more RF and microwave systems employ chips and beam leaded devices to achieve better performance, smaller size and lower costs, the need for silicon bipolar transistors with excellent RF performance and device-to-device uniformity has expanded as well.

In merging these objectives with a desire to produce devices which are easier for the hybrid builder to bond into a circuit, Hewlett-Packard has developed two new transistors. The latest additions to HP's HXTR series of devices, the HXTR-3001 and HXTR-3002, provide the VHF, UHF and microwave circuit fabricator with economical silicon bipolar transistor chips, featuring enlarged gold bonding pads. These larger pads readily permit use of 1 mil (25 μm) bonding wire, the standard diameter wire in many RF hybrid applications. Suitable for use from 100 MHz to 4 GHz, the general purpose HXTR-3001 offers typical noise figures of 1.2 dB at 500 MHz to 2.2 dB at 2 GHz. Maximum gain at 2 GHz is typically 16 dB and 1 dB gain compression power is 21 dBm at 1 GHz.

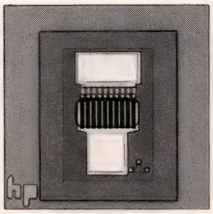
The linear power/general purpose HXTR-3002 is an extremely rugged device, typically providing 16.5 dB S_{21E} gain at 500 MHz, and 22 dBm output power with 18 dB of associated 1 dB compressed gain at 1 GHz.

Available at authorized Hewlett-Packard distributors.

Obtain further details by checking **J** *on the HP Reply Card.*



HXTR-3001



HXTR-3002

Two new application notes for radio frequency measurements

A new Application Note 286-1, **Applications and Operation of the 8901A Modulation Analyzer**, provides detailed procedures for using the 8901A in transmitter testing, signal generator calibration, broadcast monitoring, measuring VCO differential linearity, measuring residual FM noise of oscillators, separating residual AM or FM, or measuring peak modulation transients from 150 kHz to 1300 MHz.

A second new Application Note 283-2, **External Frequency Doubling of the 8662A Synthesized Signal Generator**, describes performance of the 11721A, 1280-2560 MHz frequency doubler as it affects modulation, distortion, spectral purity, conversion loss, and output dynamic range.

For your free copy of AN 286-1, check **K** *on the HP Reply Card and for AN 283-2, check* **L**.

HP HFBR-0010 link is now available for only $275

Now you can purchase HP's 10-metre fiber optic link for only $275*, saving you over 50 percent on the regular price.

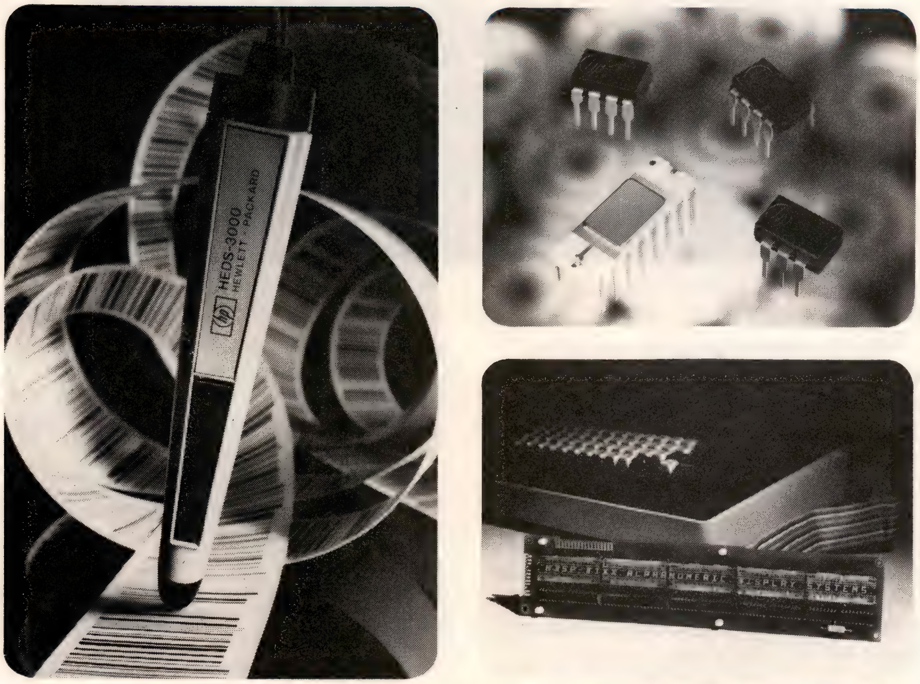
The HFBR-0010 is a complete 10-metre simplex link consisting of a transmitter, a receiver, a 10-metre connector/cable assembly, and technical literature. Because HP's system is completely plug-together and interchangeable, distances up to 1,000 metres are possible. For systems up to 100 metres, simply change cable assemblies. For longer systems, up to 1,000 metres, substitute HP's new HFBR-1002 1,000-metre transmitter. In either case, no adjustment or calibration is required.

For further details, check **M** *on the HP Reply Card.*

*Offer expires August 31, 1980
U.S.A. Domestic price

COMPONENT NEWS

New 1980 Optoelectronics Designer's Catalog is available



New products described in complete detail in the new 1980 optoelectronics catalog include the digital bar code wand (left), AC/DC threshold sensing and hermetic optocouplers (top right), and 18-segment alphanumeric display microprocessor unit (bottom right).

Intended for use as a source book in design situations, HP's new Optoelectronics Designer's Catalog includes the latest HP optoelectronic application notes, as well as complete technical information about HP's Optoelectronic products.

This 496-page catalog is sub-divided into six categories:

- **Emitters/Detectors**
- **Fiber Optics**
- **Optocouplers**
- **Solid State Lamps**
- **Solid State Displays**
- **High-Reliability Products**

Of special interest to designers will be several new product additions to the catalog. These include HP's first digital bar code wand, a 1000-metre fiber optic link with cable/connector assembly, an AC/DC threshold sensing optocoupler, a new hermetic optocoupler, 5 V and 12 V color resistor lamps, color light bar modules in single, quad and twin arrangements, and an 18-segment alphanumeric display microprocessor unit. Applications information on all of these products is included in the applications section. Photographs, package dimensions, features, operating characteristics and performance graphs provide a complete description of each component.

Other catalog features include an alphanumeric index which lists all components by part number, an introductory capabilities section on all product lines, and a selection guide for each component group giving a brief overview of the different categories. In addition, a complete listing of all HP sales and service offices and HP components franchised distributors is included.

Obtain your free copy by checking **N** *on the HP Reply Card.*

Two new application notes simplify your amplifier designs and ease your hybrid circuit assembly problems

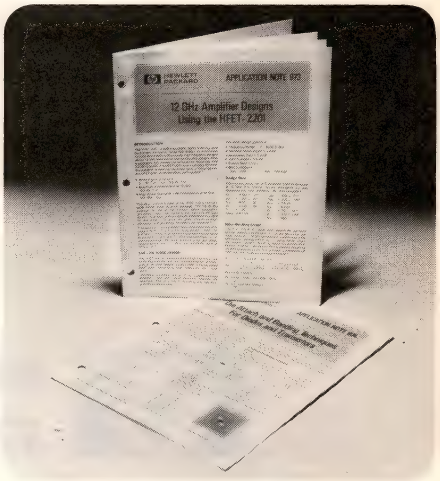
Application Note #973 describes two 12 GHz amplifier designs using the HFET-2201, a one-half micrometer, GaAs, Schottky gate, field-effect transistor. The first design, a low noise amplifier, achieves a noise figure of 3.1 dB at 12 GHz with 7.5 dB of associated gain. The second design, a high gain stage, obtains greater than 11.5 dB of gain also at 12 GHz.

This note also contains a detailed Smith Chart and computer-aided design techniques to optimize performance. Construction details for these amplifiers are also included.

The second Application Note, #974 discusses the techniques for incorporating semiconductor devices into hybrid integrated circuits. In addition to a discussion of die attach and bonding techniques for chips, this note also considers the problems of using beam lead devices, ministrips, leadless inverted devices (LID's), and microstrip posts.

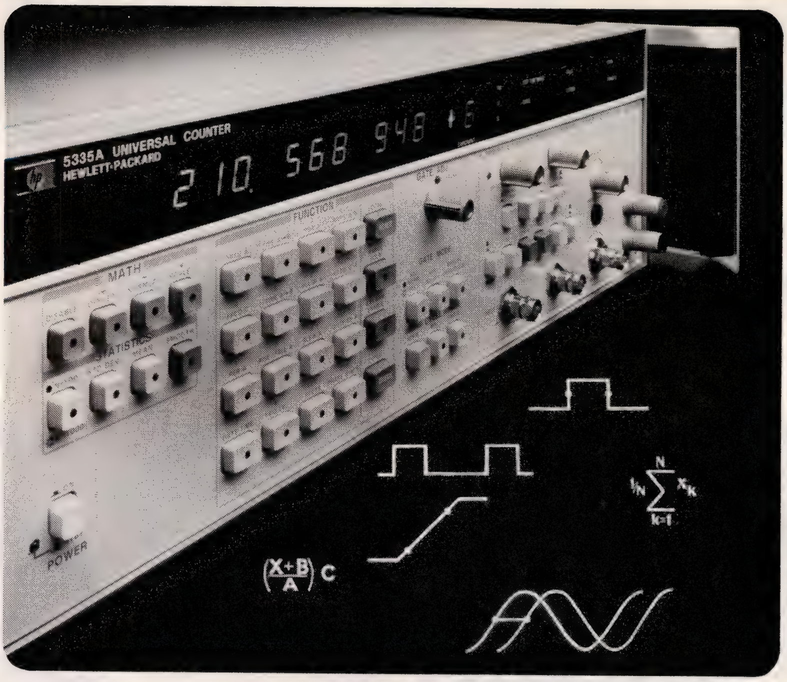
Handling precautions, as well as time, pressure and temperature settings, are presented for each package style. The note concludes with a brief description of an impedance matching technique for a LID mixer diode.

Obtain your free copy of AN #973 by checking **O** *on the HP Reply Card and AN #974 by checking* **P**.



New counter automates measurements and calculates—all at a surprisingly low cost

HP-IB



Microprocessor-based, the high performance HP 5335A Universal Counter offers more automatic features than any universal counter available today, yet it's price is much less than other counters having built-in calculating capabilities. Even its most demanding measurements, many of them new to electronic counters, are initiated at the press of a button.

In addition to very high performance in all the measurements a universal counter usually makes, HP's 5335A automatically performs measurements that require extensive data manipulation: phase, duty cycle, rise and fall times, slew rate and statistics - all via an easy-to-use front panel keyboard. The keyboard also provides for data manipulation. Offset (+, −), scale (×), and normalize (÷) data can be quickly entered to modify any measurement. This gives direct readout—up to 12 digits—in engineering terms such as RPM, pressure, flow rate and velocity. Or, it can display or add IF or difference frequencies.

High-performance frequency and time interval measurements

Despite the automatic measurement emphasis, there is no sacrifice whatsoever in measurement performance. The 5335A is a reciprocal-taking counter providing 9-digits-per-second resolution for all frequency measurements up to 200 MHz (standard) or to 1.3 GHz (optional). Single-shot, time interval resolution is an outstanding 2 ns, while time interval averaging yields a resolution down to 100 ps when measuring repetitive events.

New convenience and versatility

- Extensive auto triggering modes let the user set the trigger levels, or setting can be automatic. Exact levels are shown on the counter's LED display.
- External arming and self-arming are provided for dynamic measurements such as tone burst, pulsed RF or swept frequency up to 1.3 GHz, with excellent resolution.
- Statistical data on any of the measurements are automatic after pressing several keys to define sample size and to select mean or standard deviation values.
- Stable readout of an unstable input is provided by pressing the **Smooth** key. The counter then repetitively calculates and displays a stable weighted average of sequential measurements.

For systems use, extensive HP-IB programmability is standard, and includes all measurement functions, math and statistics.

A built-in ±1000 V, autoranging, floating input, integrating DVM is optional. Its infinitely variable integration times can optimize speed, resolution and normal mode noise rejection. HP-IB programmable, of course.

Get full details by checking ***Q*** *on the HP Reply Card.*

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hp MEASUREMENT COMPUTATION news
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May/June 1980

New product information from

HEWLETT-PACKARD

Editor:
Bojana Fazarinc

Editorial Offices:
1507 Page Mill Road
Palo Alto, California, 94304 U.S.A.

hp HEWLETT PACKARD

Dynamic faults that escape ordinary automatic test equipment are pinned down by two powerful algorithms that compare a known good board to the unit under test to isolate faults on and off the bus.

ATE system finds dynamic faults in real time

The dynamic faults that plague LSI and microprocessor-based boards are illusive but quickly captured by a combination of diagnostic techniques. A known good board (or reference board) is compared to the unit under test (UUT), under the control of a powerful software package that focuses on the most relevant board information. The soft failures can then be pinpointed with a speed and accuracy that most other types of automatic test equipment cannot match.

Unlike the stuck faults of random logic (stuck at 1, stuck at 0, open), dynamic failures result from variations in noise, temperature and other parameters of a system.

Many automatic test systems can locate and isolate static failures beyond the node, but lack sufficient memory or sufficiently flexible algorithms to analyze complex dynamic fault patterns in μP boards. The common methods and instruments for real-time fault analysis have certain advantages, but none are totally automatic. For example, logic analyzers can be clipped onto the strategic test points of a board to capture real-time data streams and so help locate faults. The technique, however, requires analyses by technical personnel who are familiar with the design and operation of the board. The equipment for emulation tests must be clipped onto the board or the microprocessor must be removed. This method lacks comprehensive software algorithms to execute automatic fault finding.

The Fluke Automated Systems 3050A test system (Fig. 1) exemplifies the alternative technique: it compares a known good board to the UUT and employs a powerful software package, the Diagnostic Management System (DMS) to isolate the faults of complex μP-based boards, automatically and in real time.

The DMS controls the interface between the operator, the UUT and the test system. It operates two

Don Cassas, Product Marketing Manager
Fluke Automated Systems
Mountain View, CA 94043

software subsystems, Autotrack and a command table, during fault tracking between bus and nonbus faults.

The Autotrack software subsystem locates nonbus faults through a sequential diagnostic walk-back algorithm. Command table software is an algorithm that locates bus faults "at speed." Autotrack and the command table are customer-programmed to select the most appropriate path for fault identification; they operate with reference to each other.

The power of DMS lies principally in its technique for comparing the UUT to a reference board. On a μP board with a 1-ms cycle time, a 1-s test can generate 23-million bits of information on the microprocessor data, address and control bus (given an 8-bit data bus and 16-bit address bus). The board must also be exercised at or near the system environment to generate a confidence level exceeding 98%. Normally, a test system would store all the possible response patterns that a given board can produce—necessiting very long test sequences and placing an unwieldly demand for system disk capacity.

1. Fluke Automated Systems 3050A Test System incorporates a new software package called the Diagnostic Management System, which can detect dynamic board faults "on the fly," a feat that is not found on most automatic test equipment.

When a known good board is used as the data base, no reference data have to be stored. Identical stimuli are applied to the board edge connects of the reference board and of the UUT at rates up to 5 MHz. The I/O data from both boards are compared in real time. In addition, a CRC signature is compiled from all I/O lines at the end of the test, which can later be used to test a single board alone. The reference board becomes an infinite dynamic "ROM." It contains the correct nodal states during any test step or microprocessor-timed subcycle.

Table 1. Valid conditional expressions

Element	True IF. . .
Mn (n=0 to 3)	Test head failed at microstep "n"
Ln (n=1 to 240)	Logic state of board edge pin "n" is high
Fn (n=1 to 240)	Board edge pin "n" in failed state
Cn (n=1 to 16)	Logic state of clip pin "n" is high (16 pin IC)
Bn (n=1 to 14)	Logic state of clip pin "n" is high (14 pin IC)
En (n=1 to 16)	Clip pin "n" in failed state (16 pin IC)
Dn (n=1 to 16)	Clip pin "n" in failed state (14 pin IC)
RE	Transfer external command received data
TC	Current test count less than saved test count
AT	Autotrack not running test
YES	Yes/Continue depressed to terminate pause
NO	No depresses to terminate pause
PASS	Tester in pass state
FAIL	Tester in fail state

The PC board supplies information that can be analyzed to isolate faults down to the component level. The DMS uses any or all of that information to determine which algorithm will most efficiently isolate the fault. First, the status of the board's microprocessor and memory read/write control lines indicate the direction of data flow—whether data are being written from the microprocessor or being read from memory, I/O controller or another bus device. Second, the address bus states that were written on or before the time of the failure can be decoded to identify the device that was being addressed.

Third, the data generated from the board as a result of the transaction can be used to evaluate the completion of an accurate command. Finally, the microstep or microprocessor time cycle at which the failure occurred can be employed to pinpoint time of the failure.

Find the fault off the bus

In the DMS diagnostic mode, when a board-edge fault is detected in the UUT, the test program stops at the first failure of an I/O pin or pins. The Autotrack subsystem of DMS scans the board-edge pins, comparing them to its board-edge priority file. Both priority and out-of-bounds indicators reside in this file, associated with each board-edge input and output pin. The file determines the diagnostic algorithm that will be required, depending on whether the failure has occurred on or off the bus.

If the fault is not on the board buses, as determined from the priority file, the Autotrack walk-back algorithm begins at the failing pin. Through the test system's interconnect file—a file containing data on how devices are connected on the board—the IC affecting the faulty output is identified, and the IC's on both the UUT and reference boards are clipped or probed. The system tells the operator where to probe, by means of a message requesting the probe action.

The test is then rerun and the nodes of the device on both UUT and reference boards are compared in real time. If a discrepancy is discovered, the next interconnected device that functionally affects the first device is identified and probed. In this way, the system walks back through the board's logic until the failing device is located. If a probing sequence moves into the dynamic or bus portion of the board's logic, the command table takes over to isolate the fault.

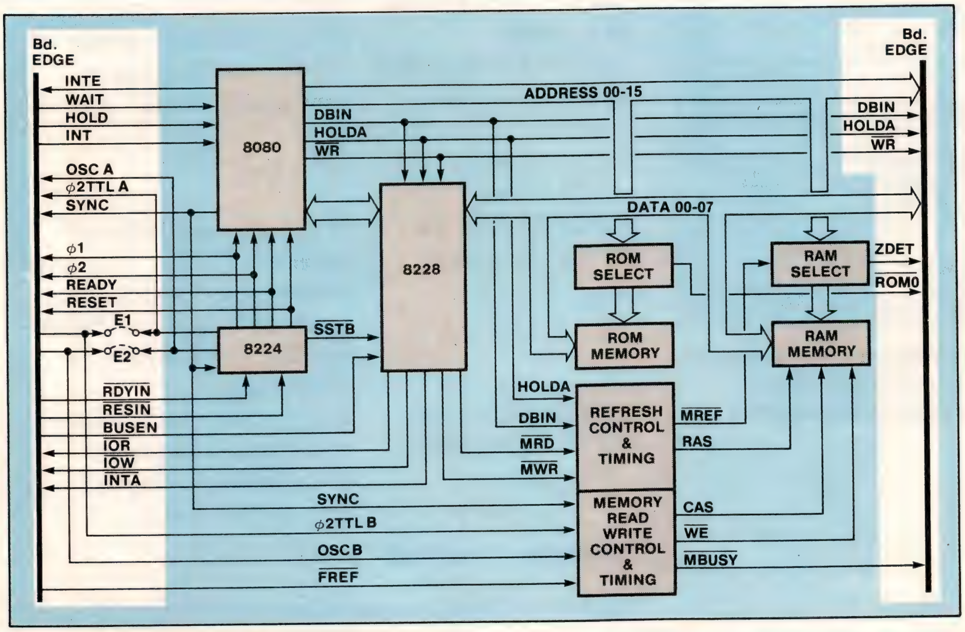
Bus-related failures

When the failure is bus related, DMS stops the test system at the first I/O bus failure. Encoded into the test program is the microstep or time cycle at which the failure occurs. DMS sets the mask on all other time cycles, which are not valid for the failure. In this way, only the data that are pertinent to the failure are identified and compared.

DMS then displays a message to the operator to rerun the test. During the next pass through the test program, DMS sets the system into an I/O "latched-states" mode. The system captures I/O data and latches it into memory at the time of failure; it then stores the status of the control, data and address buses of the UUT—even though the failure is dynamic. The system can store and compare or decode the logic states of up to 256 inputs simultaneously. Thereby, the system becomes a 256-point dynamic logic analyzer.

The UUT bus data, once stored, determine the direction that the command-table algorithm will take in isolating the fault. The command table is a progression of decision trees that are triggered by the condition of the test system. Decisions branch to prompting messages that instruct the operator to clip or probe various nodes on the UUT and reference boards when diagnostic information is required. If only specific pins of a device are pertinent to the failure path, the IC clips and probes can be masked automatically to compare valid pins and ignore others. When sufficient data are compiled to isolate the fault, a message is displayed identifying the faulty device.

If a static fault is encountered on a multi-ORed node, DMS can request, via the test system's IEEE-488 interface, that the analog instrumentation make accurate microvolt measurements. The oper-



2. In the functional block diagram of an 8080-based board, the test system's primary interface with the board is through the edge connectors, which receive test-system stimulus and provide board responses.

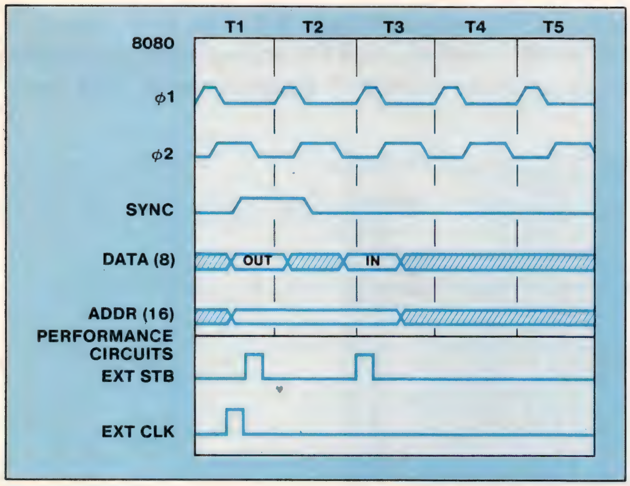
rator can then probe various IC pins along the faulty signal path to determine the device that is sinking or sourcing current. The identified IC is compared to the relevant reference-board component to determine whether it should have been addressed at that strobe cycle.

System diagnostic commands

The test programmer can guide the direction of a fault algorithm by combining DMS commands (including the decision commands, IF, THEN ELSE and END IF) into a command sequence. DMS commands can be nested into as many levels as desired. Through decision commands, the programmer gets access to the test system whenever a specified condition occurs during testing.

ADDRESS	CHIP	COMMENTS
0000 03FF	ROM 0	1K PROM - ADDRESS 0000
0400 07FF	ROM 1	1K PROM
0800 0BFF	ROM 2	1K PROM
0C00 0FFF	ROM 3	1K PROM
1000 7FFF	OPEN	
8000 8FFF	RAM BANK 0	4K RAMS (8)
9000 9FFF	RAM BANK 1	4K RAMS (8)
A000 FFFF	OPEN	

3. This memory map is contained in the sample printed board under test (Fig. 2.). The intermittent or erroneous bit in ROM 1 is a good example of the dynamic faults that other ATE have difficulty finding.



4. Timing for the microprocessor on the printed-circuit board under test is another aspect of board operation easily accessed and diagnosed by the Diagnostic Management System software.

The IF command begins the conditional structuring of a decision sequence. It is triggered by a valid external condition during testing. Information on valid-condition triggering is coded into the data field and can be set to execute on a bus-state noncomparison, on a latched-state data match, on a board's particular time subcycle or on a variety of other conditions (see Table for valid conditional expressions).

All of the logic and failure states in the Table are evaluated when the IF conditional expression is evaluated. They are fetched from the test head when processing of the IF command begins. Once the command has been executed, a nesting depth counter is incremented to track the command sequence. If the IF conditional expression is evaluated as "true," the THEN following the IF command is executed, and its conditional expression is initiated.

The EN (End If) command is the complement of the IF command. When it is encountered in the command sequence, it decrements the depth counter. The EL (Else) command is executed when it follows an IF command and its conditions have not been met during the command sequence.

The following sample program demonstrates the basic structure of a decision table. It shows where command sequences are located and which are executed when.

OPERATION: IF *DATA:* "conditional expression" *OPERATION:* THEN *DATA:* comment	The command sequence contained here executes if an evaluation of the IF conditional expression produces a "true."
• • •	
OPERATION: EL *DATA:* comment • • • •	If the above conditional expression when evaluated produces a "false," the command sequence following the EL operation is performed.
OPERATION: EN *DATA:* comment	When either of the above operations completes, program control transfers to this point.

Decisions, Decisions

The conditional expressions contained in the Table are all associated with DMS commands and can be concatenated using various logical constructs: AND, OR and NOT. The constructs add flexibility to I/O pin conditioning and command table execution, as demonstrated by the following:

```
OPERATION: IF
DATA: L1 and L3 AND NOT L4
```

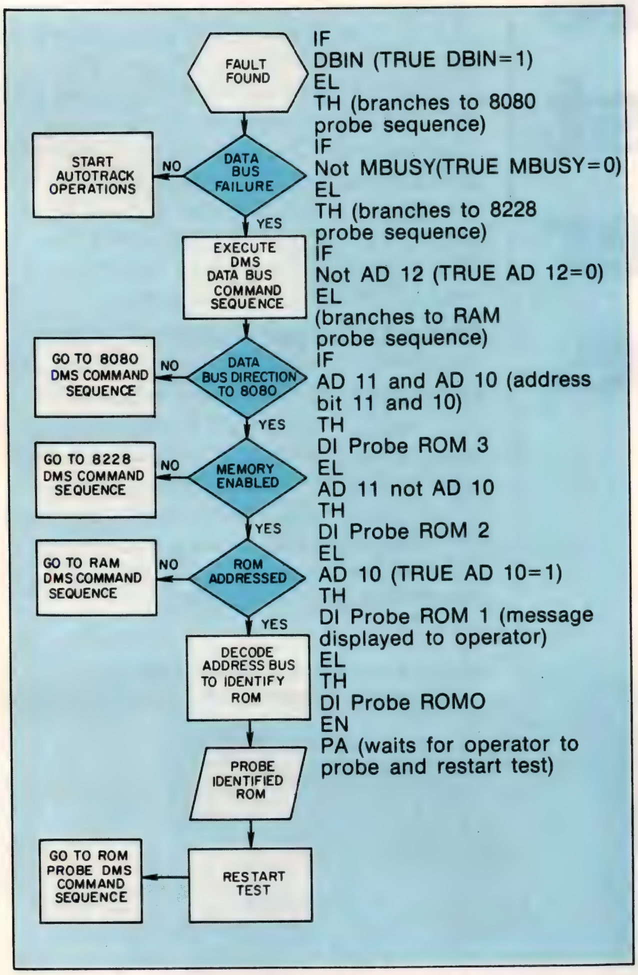
The above IF condition is true, if the logic states of board-edge pins 1 and 3 are high and 4 is low.

```
OPERATION: IF
DATA: C1 AND C6 AND NOT
E12 OR E13
```

This statement is true, if the logic states of clip pins 1 and 7 are high and pin 12 is not in the failed state or if pin 13 is in failed state.

```
OPERATION: IF
DATA: YES
```

The above statement is true, if the operator depressed Yes/Continue to end the last Pause command.


FAULT FOUND
DATA BUS FAILURE
NO
START AUTOTRACK OPERATIONS
YES
EXECUTE DMS DATA BUS COMMAND SEQUENCE
DATA BUS DIRECTION TO 8080
NO
GO TO 8080 DMS COMMAND SEQUENCE
YES
MEMORY ENABLED
NO
GO TO 8228 DMS COMMAND SEQUENCE
YES
ROM ADDRESSED
NO
GO TO RAM DMS COMMAND SEQUENCE
YES
DECODE ADDRESS BUS TO IDENTIFY ROM
PROBE IDENTIFIED ROM
RESTART TEST
GO TO ROM PROBE DMS COMMAND SEQUENCE

```
IF
DBIN (TRUE DBIN=1)
EL
TH (branches to 8080
probe sequence)
IF
Not MBUSY(TRUE MBUSY=0)
EL
TH (branches to 8228
probe sequence)
IF
Not AD 12 (TRUE AD 12=0)
EL
(branches to RAM
probe sequence)
IF
AD 11 and AD 10 (address
bit 11 and 10)
TH
DI Probe ROM 3
EL
AD 11 not AD 10
TH
DI Probe ROM 2
EL
AD 10 (TRUE AD 10=1)
TH
DI Probe ROM 1 (message
displayed to operator)
EL
TH
DI Probe ROMO
EN
PA (waits for operator to
probe and restart test)
```

5. The identity of the faulty device appears when the DMS follows the strategy indicated by the flow chart (left) and command sequence (right) for locating the bad bit at 07FF.

The uses of the command table are typified by the simulation of a sample failure on the microprocessor block diagram (Fig. 2). The memory map (Fig. 3) denotes representative address locations for memory elements on the sample board. Fig. 4 represents the 8080 CPU timing.

The failure in Fig. 2 is a bad data bit at location 07FF, written on the bus from memory and discovered at test step 185. Since the command table can be initiated by a particular I/O failure condition, rather than by a step number, the test step is irrelevant. The operator initiates the test of the board and places the test system in the "stop-on-fail" mode. When the test encounters step 185, the I/O pin connected to the data bus indicates a noncompare between the UUT and the reference board, halting the test system at the moment of failure.

Diagnostics take over

The test program branches to the DMS command sequence. The branch is enabled by a CPU request encoded into the command table and triggered by the bus failure. The DMS command sequence then takes control over the testing operation, working in conjunction with the test program. The direction the fault algorithm takes is determined by the external data conditions that are met as the diagnosis continues through the board's logic.

The UUT's I/O data are latched into the test system's memory at the time of the failure and are evaluated by DMS to identify the faulty device. The following strategy comes into play (see flow chart and command sequence in Fig. 5).

First, the direction of the data bus is determined and the logic state of the DBIN signal is identified. (When DBIN is low, data are being written from the 8080.) For this failure, DBIN would have to be high. Next, the enabled device that is writing onto the data bus is identified by type (I/O, memory, etc.). In this case, MSBUSY equals a low and memory is enabled. Finally, the address bus is decoded to determine the type of memory device (ROM or RAM) and the specific device of that type (ROM 2, etc.) that was addressed. The final failure identification is made by decoding the address bits. In this case, the address is 07FF, which satisfies the EL statement and identifies ROM 1.□

How useful?	Circle
Immediate design application	541
Within the next year	542
Not applicable	543

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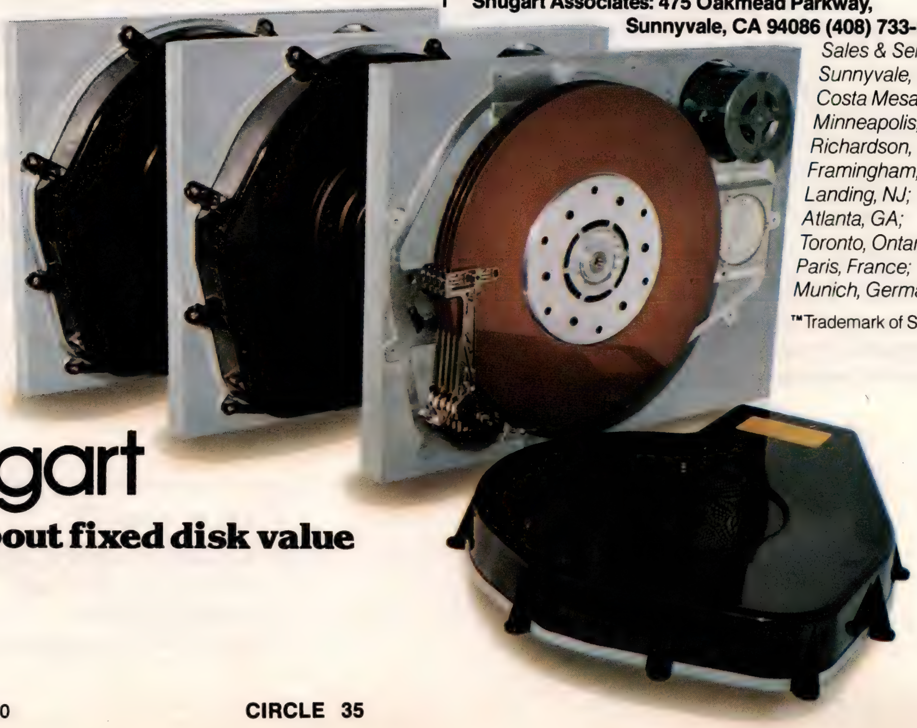

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CIRCLE 35

With a conversion time of less than a microsecond, a self-contained successive-approximation analog-to-digital converter interfaces directly with microprocessors for maximum system throughput.

Monolithic 8-bit ADC matches micro speed

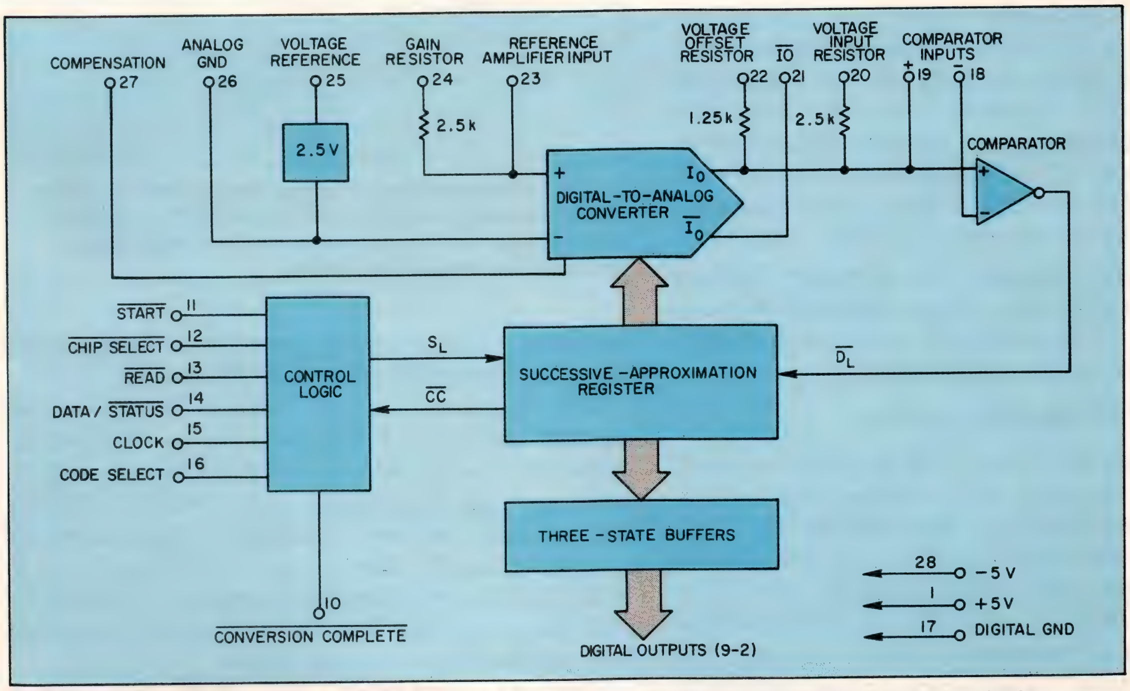
For the first time, a monolithic self-contained 8-bit successive approximation analog-to-digital converter completes a conversion in less than a microsecond. The Am6108, which interfaces directly with microprocessors, is so fast that system throughput is limited only by the microprocessor's speed—not by converter delays. The a/d chip is fully self-contained, integrating a precision digital-to-analog converter, a high-speed comparator, a stable bandgap voltage reference, a successive-approximation register, three-state outputs and control logic, as well as matching, gain, input and offset resistors.

Gerard McGlinchey, Senior Design Engineer
Advanced Micro Devices
901 Thompson Pl., Sunnyvale, CA 94086

The Am6108 operates from standard ±5-V supplies. It performs conversions on unipolar inputs can range from 0 to +10 V or +5 V, and bipolar from −5 to +5 V.

The integration of so many diverse circuit blocks (Fig. 1)—particularly precision analog circuits and compatible high-performance logic—has seldom been possible without special processing. However, the Am6108 employs a standard linear bipolar process with a dual-layer metallization that creates a compact layout in a small die, just 102 × 140 mils. Standard processing ensures device availability and makes for predictable reliability.

Also contributing to the performance of the Am6108 is a novel nonsaturating logic form, called



1. **Fully-self-contained, the high-speed Am6108 8-bit analog-to-digital converter integrates, on a single chip, a precision DAC, comparator, voltage reference, successive-approximation register, control logic and output buffers.**

linear differential logic. Similar to emitter-coupled logic, LDL provides even greater density and better performance. With LDL, translator circuits give TTL levels at all inputs and outputs.

LDL—a novel high-speed logic

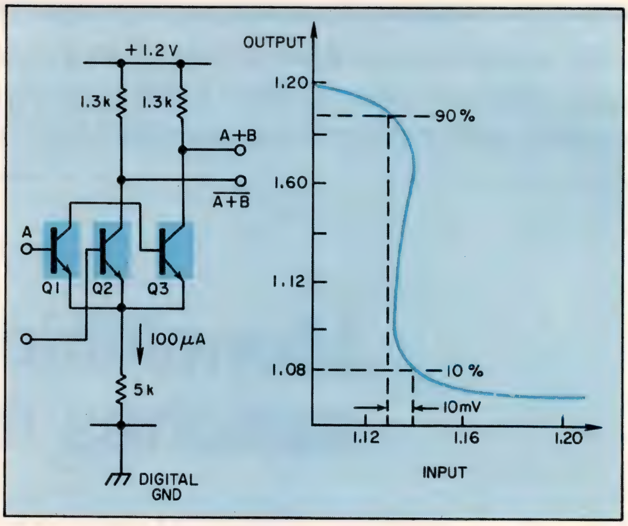
Fig. 2 shows how LDL works for a two-input NOR/OR gate. A bandgap voltage of 1.2 V supplies the logic gate to give an almost constant on-to-off current ratio over the converter's operating temperature range. LDL features a logic swing of 130 mV, which is adequate to steer almost all the gate current between transistors Q_3 and either Q_1 or Q_2. The gate is self-biased because the base of Q_3 is connected to the collectors of Q_1 and Q_2. The connection simplifies the layout of the gate and provides positive feedback.

With a low logic input of 1.07 V applied to the bases of Q_1 and Q_2, transistor Q_3 is on, and Q_1 and Q_2 are off. Transistor Q_1 turns on when a logic transition from 1.07 to 1.2 V is applied to its base. The positive feedback ensures that Q_3 turns off rapidly. The collector-base junction of Q_1 is forward-biased by the logic swing of 130 mV, which is not sufficient to cause Q_1 to saturate. With LDL, complementary NOR and OR outputs are also possible.

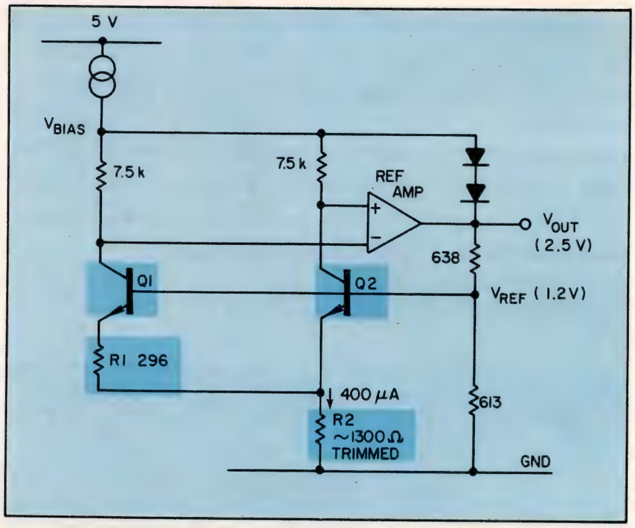
The LDL gate operates at a constant current, thereby avoiding power-supply glitching and potential interaction between the logic and sensitive analog circuits. The constant-current operation, together with careful layout, leads to excellent noise immunity, even with a low logic swing.

The digital inputs and outputs of the Am6108 are TTL-compatible. The high-impedance inputs consist of a differential pair referenced to the TTL threshold of 1.2 V. The TTL threshold is constant with temperature, in contrast to the threshold obtained when two base-emitter voltages are stacked, as in a conventional TTL circuit. The digital inputs are level-shifted internally to the levels in the linear differential logic.

For its digital outputs, the converter employs conventional three-state outputs. Because they can each drive two TTL loads, the outputs can be connected directly to the system bus.



2. The Am6108 employs linear differential logic, a novel nonsaturation logic form that is even denser than emitter-coupled logic and works with a logic swing of only 130 mV. This LDL circuit is a two-input NOR/OR gate.



3. The on-chip bandgap voltage reference of the AM6108 is immune to supply variations as large as ±10% and to load variations from 1 to 5 mA. At wafer sort, the ratio of R_2/R_1 is adjusted by trimming resistor R_2.

The on-chip DAC has 8-bit accuracy

The performance of any a/d converter is dominated by the accuracy of its analog components, particularly the DAC. In the Am6108, the DAC consists of a reference amplifier, binary weighted current sources and current switches. The gain resistor and reference amplifier convert the voltage reference into an accurate reference current. The reference amplifier, which is compensated externally with a single capacitor, is designed for low voltage-offset and low input offset bias currents. The binary-weighted current sources are derived from a combination of straight R and R/2R scaling.

The matching of emitter resistors determines the current accuracy of the DAC. These diffused resistors provide better than 8 bits of accuracy without any trimming. High-speed current switches steer the bit currents between the DAC's complementary outputs (IO and $\overline{\text{IO}}$). The full-scale IO current is 4 mA, and the complementary $\overline{\text{IO}}$ current can be tied to the chip's analog voltage input pin to maintain a constant load at the signal voltage source.

During a conversion, the on-chip comparator senses the summing node and provides a logic output, which determines whether the bit current under test should be retained or not. The comparator inputs are clamped by Schottky diodes, to reduce the speed at which the DAC must slew.

The comparator can respond to half of a least-significant bit of overdrive (20 mV) in less than 5 ns. The bias current for each comparator changes proportionately with temperature, so that the resolution of the comparator does not change with temperature. The low offset voltage and low bias current of the comparator contribute to the converter's excellent accuracy.

An enabled latch holds the comparator output in a state independent of the analog input. First, the summing node is compared with the inverting input while the system clock is low. Then, a high-going clock edge enables the latch by transferring current from the input stage to the latch stage.

A bandgap reference for stability

The voltage reference on the Am6108 is an improved bandgap reference. Besides providing good stability with temperature, the voltage reference is immune to supply variations of ±10% and load variations from 1 to 5 mA.

In its most basic form, this reference (Fig. 3) consists of just four devices: transistors Q_1 and Q_2, and resistors R_1 and R_2. At balance, the collector currents of Q_1 and Q_2 are equal. Since Q_1 operates at a lower current density than Q_2, the difference in the two base-emitter voltages appears across R_1. The absolute value of Q_1's base-emitter voltage is not constant, and the variations require compensation. At wafer sort, the ratio of R_2/R_1 is adjusted by trimming R_2, through the selective blowing of metal-link fuses.

The Am6108 requires nine clock periods to complete a conversion. The unknown analog input is applied to the input resistor. A conversion is initiated by holding $\overline{\text{START}}$ and $\overline{\text{CHIP SELECT}}$ low during a clock low. $\overline{\text{CONVERSION COMPLETE}}$ toggles high to indicate that a conversion is in progress. During the next eight clock periods, the analog input is compared with each of the eight binarily-weighted current sources.

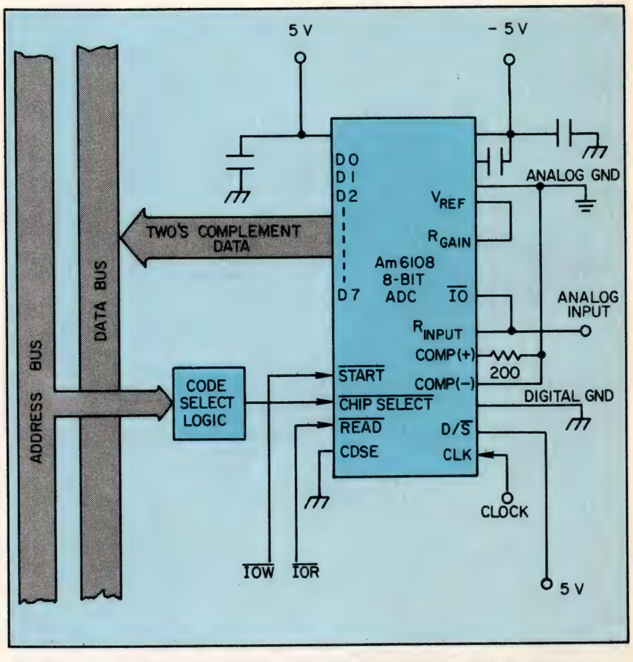
The successive-approximation register is initially reset with all the bit currents, except the most-significant bit current, steered to IO. Each bit is successively removed on a low-going clock edge. After comparing the summing node with the inverting input, the comparator delivers a digital output to the register cells. Depending upon the result of the comparison, the bit current is removed from or steered to IO. When the least-significant bit has been tested and the result latched in the register cells, $\overline{\text{CONVERSION COMPLETION}}$ toggles low to indicate the end of the conversion. A read operation makes the binary data, which are latched in the register cells, available on the three-state outputs.

Minimizing on-chip delays

The major factors that determine conversion speed are the comparator delay, the logic delay and the DAC settling time. In many converters, these delays are all significant. In the Am6108, high-speed logic ensures that the logic delays in the register cells are negligible; and good design techniques make the comparator delay negligible. Therefore, the DAC settling time defines the chip's conversion speed.

High-speed current switches ensure that internal delays in the DAC are also negligible. The most stringent requirement for settling time occurs when the MSB is switched. Before a valid comparison can be made, the summing node must settle to with a ±1/2-LSB error band. The time constant associated with the summing node depends on the parasitic capacitances and the input resistance.

A high-speed process minimizes the parasitic capacitances. The addition of a noncritical 200-Ω external resistor between the summing node and ground reduces the chip's 2.5-kΩ input resistance, because the summing node is a virtual ground. The



4. Because of its on-chip three-state buffers, the Am6108 interfaces easily to any presently available microprocessor. The chip finishes a conversion in less than 1 μs, so processor interrupts can be avoided.

extra resistor also reduces the error signal that the comparator must resolve. However, the comparator has adequate gain and accuracy to respond rapidly, even with reduced overdrive.

The Am6108 provides 8 bits of resolution, but the part is linear to better than 9 bits. This tight linearity guarantees that the part has no missing codes. Also, offset and gain errors are minimal.

Straight conversion on a bipolar input requires the DAC to source current for a negative input and to sink current for a positive input. However, as is the case for all conventional DACs, the Am6108's on-chip DAC can only sink current. Bipolar inputs are accommodated by connecting the offset resistor to the voltage reference. This connection provides a 2-mA current source that functions to offset the DAC's output current.

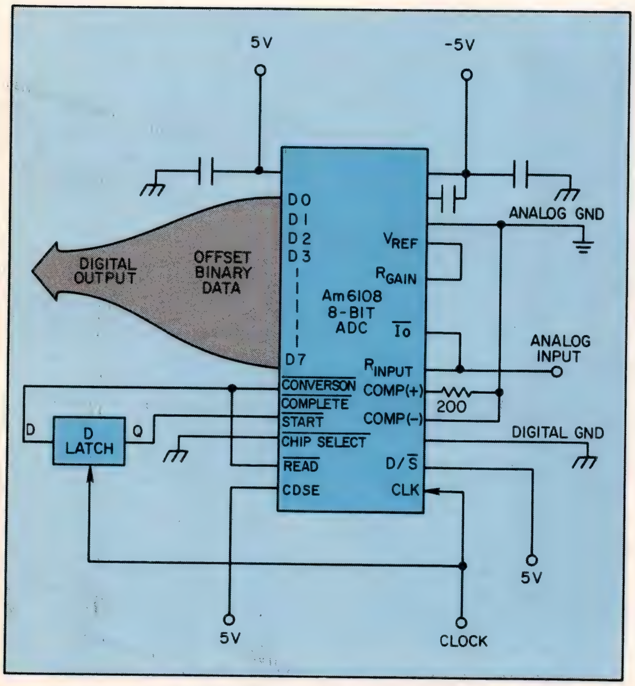
Designing with a fast a/d

Interfacing the Am6108 to any presently available microprocessor is easy (Fig. 4). Many a/d converters are so slow that processor interrupts have to be used. Interrupt servicing, which is not necessary for the fast Am6108, is very costly both in terms of microprocessor throughput and in conversion time.

The Am6108 has five input control lines—$\overline{\text{CHIP SELECT}}$, $\overline{\text{START}}$, $\overline{\text{READ}}$, DATA/$\overline{\text{STATUS}}$ (D/$\overline{\text{S}}$) and code select (CDSE) and a $\overline{\text{CONVERSION COMPLETE}}$ output. Only the $\overline{\text{IO WRITE}}$ ($\overline{\text{IOW}}$) and $\overline{\text{IO READ}}$ (IOR), which are available in every microprocessor system, are needed for interfacing. The microprocessor starts a conversion by writing to the Am6108. Because of the speed of the Am6108, the microprocessor can immediately follow the $\overline{\text{IOW}}$ with an $\overline{\text{IOR}}$. Thus, the converter operates under microprocessor control merely by successive writes and reads. The data are made available on the eight three-state outputs.

The $\overline{\text{CHIP SELECT}}$ control line can be a committed address line or, in a larger system, an address line decoded by dedicated control logic. The D/S control line opens the option of making status information available on the data bus. By testing this single status bit, the processor can determine whether a conversion is still in progress or complete. This option is relevant only in systems where the processor cycle times are significantly faster than 1 μs. Data format is determined by CDSE. Data are available in either two's complement or binary offset coding. In a typical application D/$\overline{\text{S}}$ is tied high, and CDSE is tied low to provide two's complement data. The Am6108 is selected by bringing $\overline{\text{CHIP SELECT}}$ low. With $\overline{\text{CHIP SELECT}}$ low, the $\overline{\text{IOW}}$ control line provides start and the $\overline{\text{IOR}}$ provides read.

The Am6108 also operates in a stand-alone configuration (Fig. 5), with only a single D-type latch. CODE SELECT and D/$\overline{\text{S}}$ can be pin-selected to provide data, for example, in binary-offset format. For continuous conversions, the $\overline{\text{START}}$ and $\overline{\text{READ}}$ control lines are derived from the $\overline{\text{CONVERSION COMPLETE}}$ output, which is connected directly to the READ input. Data are available on the data bus for one clock period until the output of the D-type latch goes low, which resets the converter and starts a new conversion. This mode of operation is suitable for real-time applications that demand the large bandwidth provided by the Am6108.□



5. For stand-alone operation, the Am6108 requires only one external D-type latch. Output data are available in two's complement coding by tying CODE SELECT low or in binary offset coding by tying CODE SELECT high.

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How useful?

	Circle
Immediate design application	544
Within the next year	545
Not applicable	546

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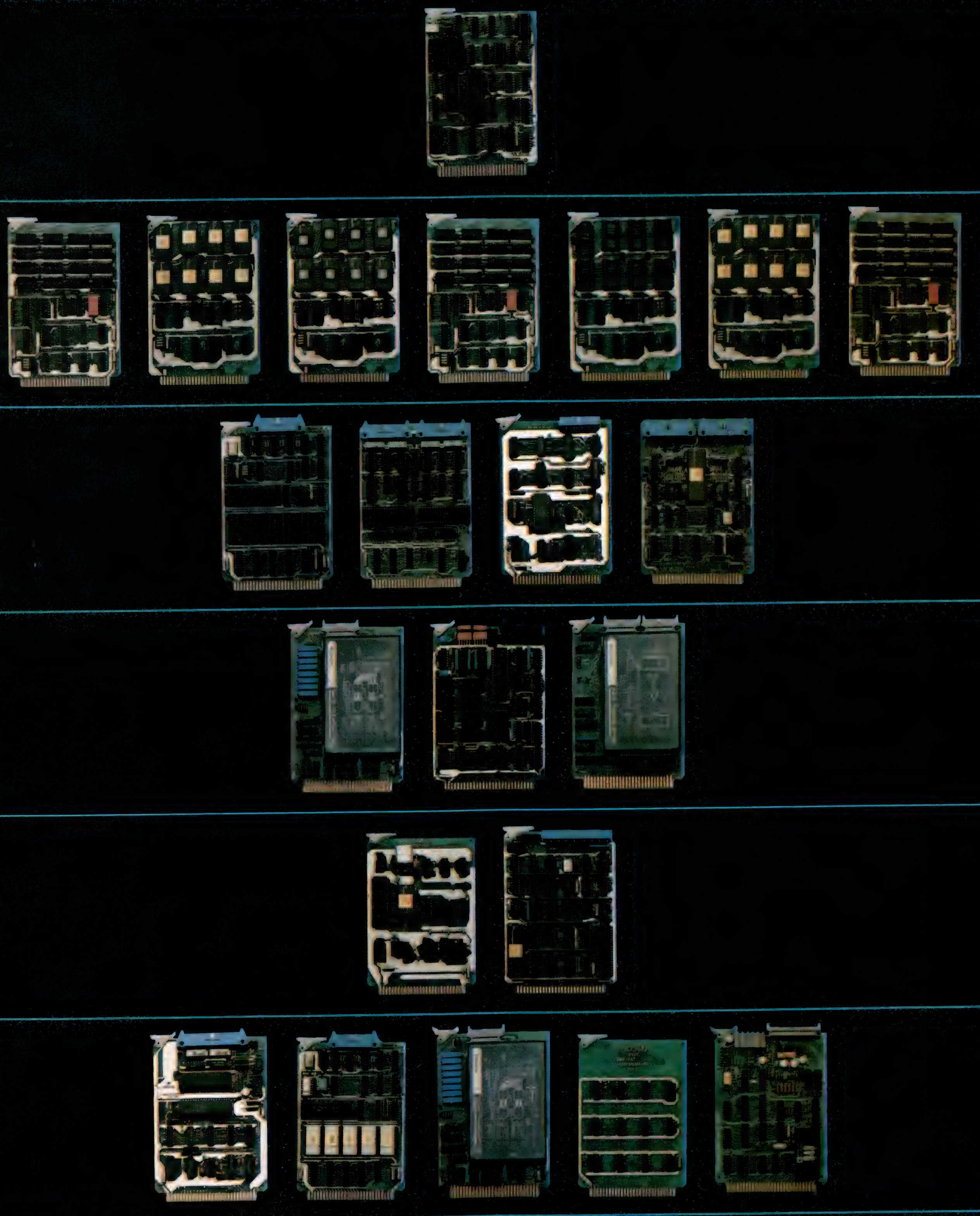

Mostek's MD Series: Proven STD-Z80 BUS compatible cards simplify microcomputer design.

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Mostek MD Series: Think of them as design tools you can buy one at a time.

The strongest advantage of the Mostek MD Series is that it's designed like a set of compact precision tools. Each card has a singular specific function and can be bought separately. Yet all the cards work together because the STD-Z80 BUS uses a motherboard interconnect system.

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Then, if you want to expand or modify your system, you simply add, delete, or change MDX cards in the card cage.

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Mostek MD Series

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MD-SBC-1	Z80 based single board computer	
MDX-DRAM 8	8K Dynamic RAM	MEMORY GROUP
MDX-DRAM 16	16K Dynamic RAM	
MDX-DRAM 32	32K Dynamic RAM	
MDX-EPROM/UART	Comb. EPROM/UART	
MDX-UMC	Universal Memory Card	
MDX-SRAM 4	4K Static RAM	
MDX-SRAM 8	8K Static RAM	
MDX-EPROM-16	EPROM Module	
MDX-PIO	32-Bit programmable parallel I/O	I/O GROUP
MDX-SIO	2 channel programmable serial I/O	
MDX-FLP	Floppy disk controller	
MDX-A/D 8	8-Bit A/D	
MDX-D/A 8	8-Bit D/A	
MDX-AIO	Analog 10-Bit Input; 8-Bit Output	
MDX-A/D 12	12-Bit A/D Converter	
MDX-D/A 12	12-Bit D/A Converter	
MDX-DEBUG	EPROM/UART with 10K ROM-based software	ACCESSORY GROUP
MDX-SC/D	System Controller and Diagnostic Board	
MDX-INT	Interrupt Expander and Timer Board	
MDX-SST	Hardware single step	

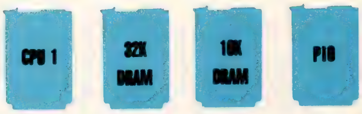
PROBLEM: A bank's main check processing system can capture and process millions of magnetically encoded checks. However, before the computer can process these checks the dollar amount must be magnetically encoded on each check, a slow and costly manual operation. In addition, checks are handled several more times for sorting and filing. Then mailed to the customer which also increases cost. Is there a better way?

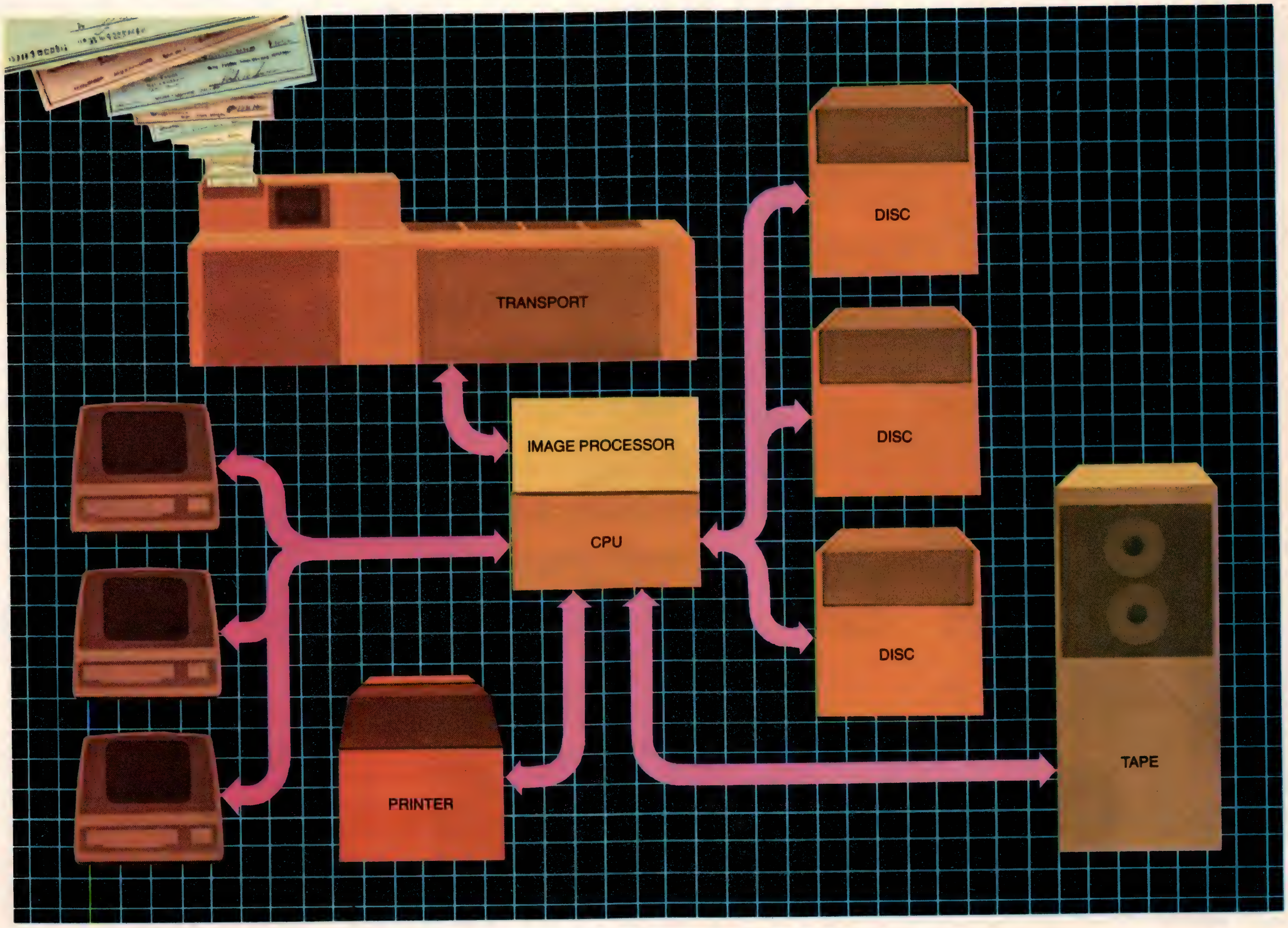
SOLUTION: A new image processing system developed by Dallas-based BancTec, Inc. This system handles a stored digital video image of the check instead of the check itself. The Image Processing System eliminates nearly all manual handling. It also eliminates returning checks to the bank's customers because it provides images of the checks on the customers' statements instead. The versatility of the system is enormous and the bottom line impact is increased efficiency with considerable time and cost savings.

According to Gene Dempster, principal software engineer, BancTec chose Mostek's MD Series because "they offer bite-size chunks that are versatile enough to perform many functions depending on where we use them in the system. They saved us from having to design a different piece of hardware for each function. Using one standard CPU board and one standard memory board, we reduced our inventory and made servicing cheaper."

"In addition, the Z80 (the microprocessor base for the MD Series) offers better string management instructions than any other microprocessor we saw. We estimate that we saved between four and six man-months by buying the Mostek boards off the shelf. As a result, we were able to bring the system to the market that much sooner."

There are four MD Series boards in the BancTec Image Processing System: The CPU 1, 32K DRAM, 16K DRAM and PIO. These are used in three separate areas of the system (transports, Fax terminals and image processor) to perform a variety of tasks.





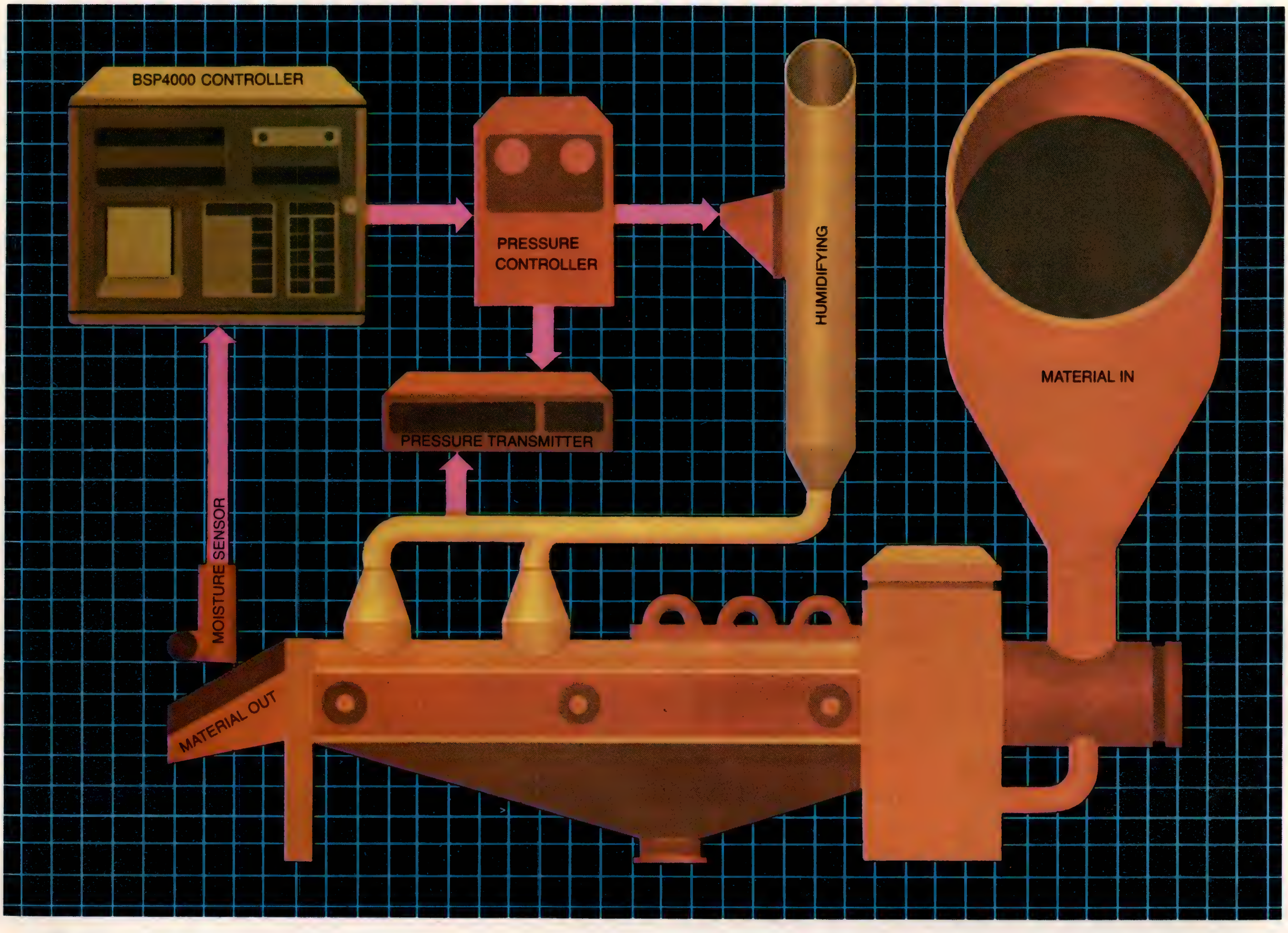
PROBLEM: In many manufacturing processes, monitoring moisture content is critical, either in finished goods or in intermediate processing steps. Overdrying can waste raw materials and energy. Underdrying can result in costly reprocessing or outright product loss. What's needed is some method to measure moisture content within a very narrow range.

SOLUTION: The BSP 4000 Moisture Control System. Developed by the Moisture Register Company, this instrument monitors and controls moisture content on a continuous basis. It eliminates both underdrying and overdrying because it allows the user to enter calibration data and control parameters, and set minimum/maximum limits via keyboard or optical card reader, almost instantaneously.

In designing the BSP 4000, engineering manager and chief designer Charles Blevins aimed for a digital system with "smart formatting easily changeable by software."

"After a false start with another board family where the I/O needed wasn't available, we decided on Mostek's MD Series. The form factor became a real determinant; only Mostek had the compact, smaller-sized boards we needed. It was an excellent choice. Not only did the MD Series reduce our development time by at least 50%, it saved us money as well."

The Moisture Register BSP 4000 uses five Mostek MD Series boards: the CPU 1, 2 PIO boards and 2 EPROM/UART boards. These handle all the product's data transmission chores, along with D/A and A/D conversion.



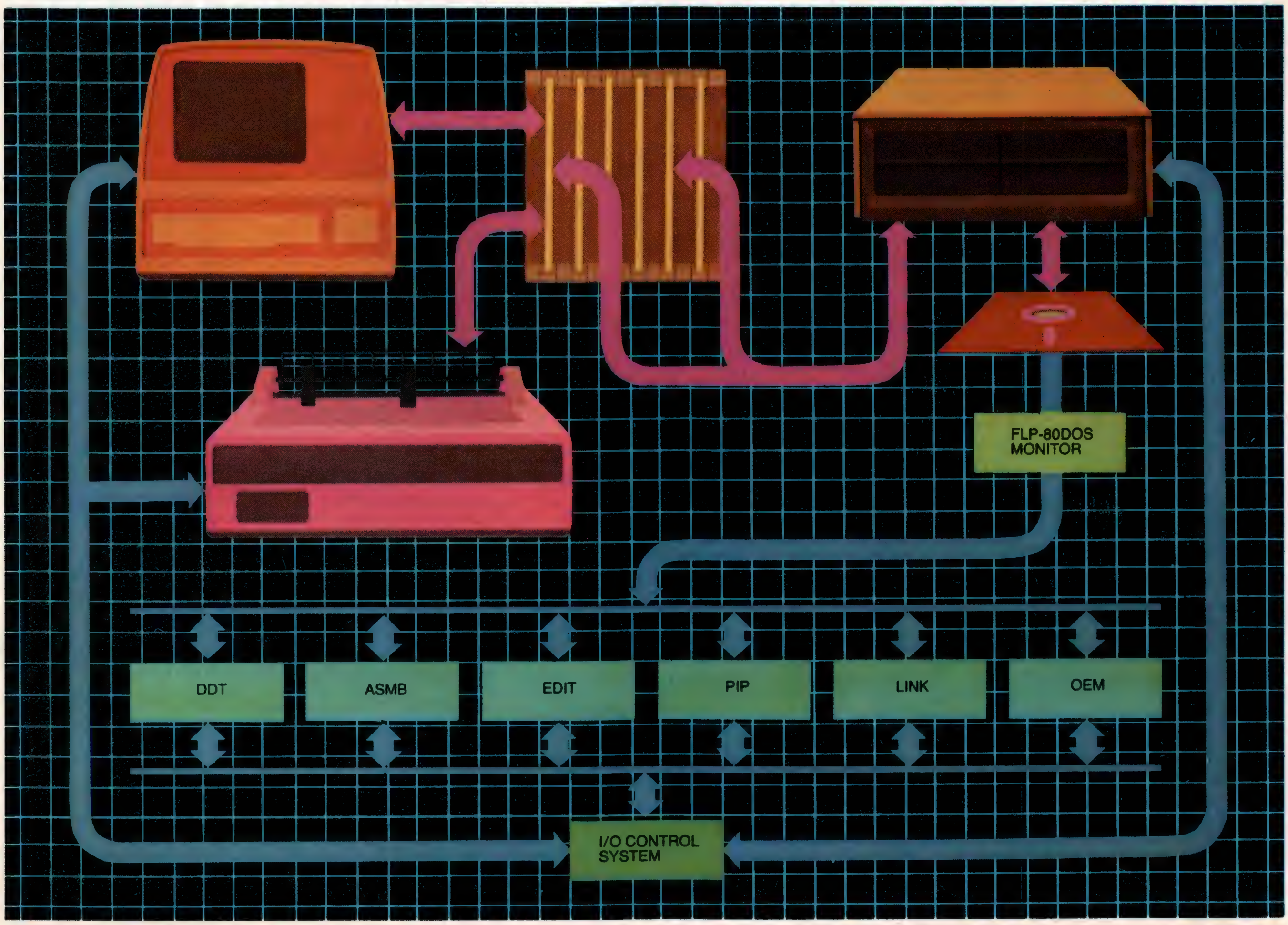
PROBLEM: Granted, the MD Series boards can virtually eliminate hardware development time. But what about time-intensive software development?

SOLUTION: Mostek's MD Series Software development systems. Seven different models are available, including Mostek's powerful Matrix™ dual floppy disk-based computer. You can buy as little or as much as you want, depending on your needs. High level languages include BASIC and FORTRAN.

Or you can build your own software development system using MD Series cards. By supplying the equipment you have, like CRT's and line printers, you can cost effectively tailor a system to your budget. Plus you can reuse the MDX cards from the development system once the software task is accomplished.

To configure a typical development system from MD cards, you need an MDX-CPU 1, two MDX-DRAM32s, MDX-FLP, MDX-EPROM/UART, wirewrap boards, cables, and a PROM programmer. Plug the cards into a MDX-card cage with power. Connect the system to your CRT, line printer and floppy disk drives (the MDX-FLP controls up to four single-sided drives). Purchase Mostek's FLP-80DOS disk-operating system, and insert those diskettes into two drives. You now have one of the industry's most powerful software development systems.

Mostek also has complete diagnostic software to give you even more flexibility. MEDEX 80 troubleshoots your system to the board level. MITE-80 enables your MDX system to execute multiple programs. And supplementing MITE-80 is BIOS, a selection of routines to help you design I/O drivers.



Mostek MD Series: All the tools for a smart design.

Before you define your next design path, consider the expandable, tool-like approach of the Mostek MD Series. For both hardware and software needs, it minimizes front-end investment. And then, enables you to respond economically and quickly to changing product definition and/or market conditions. For the 1980s, it's the smart way to design.

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Design

When switching rise times get faster than 1 ns, switch from conventional open wiring to impedance control by transmission-line technology and to crosstalk control by shielding and guiding the signal paths.

Transmission-line methods speed 1-ns data along

Interconnection problems—mainly impedance matching and crosstalk—multiply in direct proportion to the switching speed of the signals handled and to the length of the transmission pathways. And with switching rise times going higher than 1 ns, the problems become acute. But flat cables, twisted pairs and coaxial cable can solve the transmission problems between racks, boxes and boards, and microstrip techniques can take care of on-the-board connections. These methods make it possible to apply impedance control by transmission-line technology and crosstalk control by shielding and guiding the signal paths.

As a pulse's rise time approaches the delay time of its transmission path, source-to-path and path-to-load impedances must be matched to prevent signals from being corrupted. With the propagation velocity of most cables more than 1 ns/ft, cable-impedance matching becomes more urgent as signal rise times drop below 10 ns. At 1 ns, even the short distances in connectors and between components on circuit boards begin to affect performance. Fortunately, it is easy to calculate when conventional open-wiring must be replaced by some form of controlled-impedance interconnecting system.

Because any real signal pulse has a finite rise time, an upper frequency limit can be calculated based on a Fourier time-to-frequency analysis. The upper frequency limit is commonly expressed as

$$F_c = 0.35/T_r$$

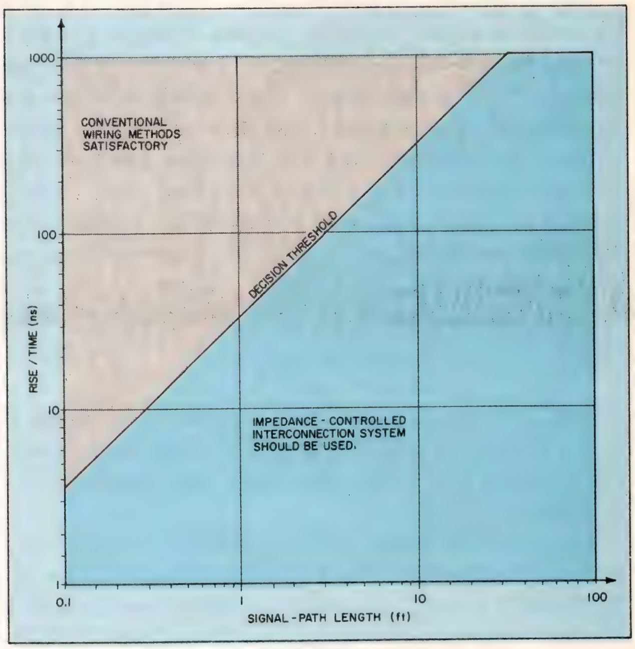
where F_c is the highest frequency that must be transferred by the interconnect system to keep the pulse shape from being significantly degraded, and T_r is the rise time of the leading edge of the transmitted pulse.

When the wavelength corresponding to F_c is at least 100 times longer than the physical length of the transmission path, the signal can pass safely over conventional open wiring without impedance control or shielding. The wavelength is calculated by

$$\lambda_c = V/F_c,$$

where λ_c is the cutoff wavelength and V is the velocity of signal propagation (about 1 ns/ft).

Fig. 1 is a graphic representation of these relationships showing the decision threshold. Above the decision-threshold line, these interconnect problems are minimal, so conventional wiring is sufficient. However, the high-speed region electronic systems



1. The decision-threshold line separates the rise-time/signal-path-length relationship into two regions: One does and the other does not require controlled-impedance interfacing. Thus, at rise times of 3.5 ns or less and signal-path lengths of about 0.1 ft, which are normal distances found within the confines of PC boards, controlled-impedance interconnecting is needed to avoid discontinuity problems.

Jim Fetterolf, Basic Products Manager
AMP, Inc.
Harrisburg, PA 17105

are heading into—below the line—requires an interconnection system with two controlled ingredients: impedance and crosstalk control. Impedance control provides a reflection-free, maximized in-phase transfer of energy from the signal source to the receiving circuit. Shielding limits pickup from, or radiation of, crosstalk and other interference, and guided signal paths allow separation or balancing of the undesired signals to reduce interference.

Fortunately, impedance and crosstalk/noise controls can be considered independently, which makes it easier to tackle the somewhat more complex impedance-matching problem first.

All impedances should match

In a perfectly matched circuit, both source and load at the ends of a transmission line match the characteristic impedance of the line. In practice, however, compromises must be made in the match, which introduces impedance discontinuities.

A transmission line's properties can be described (Fig. 2a) by its delay (T_D), characteristic impedance (Z_o) and attenuation (α). If the attenuation can be neglected, then

$$T_D = (LC)^{1/2}$$
$$Z_o = (L/C)^{1/2}$$

where L and C are functions of the width, thickness and spacing of the line's conductors and the dielectric constant of the insulators.

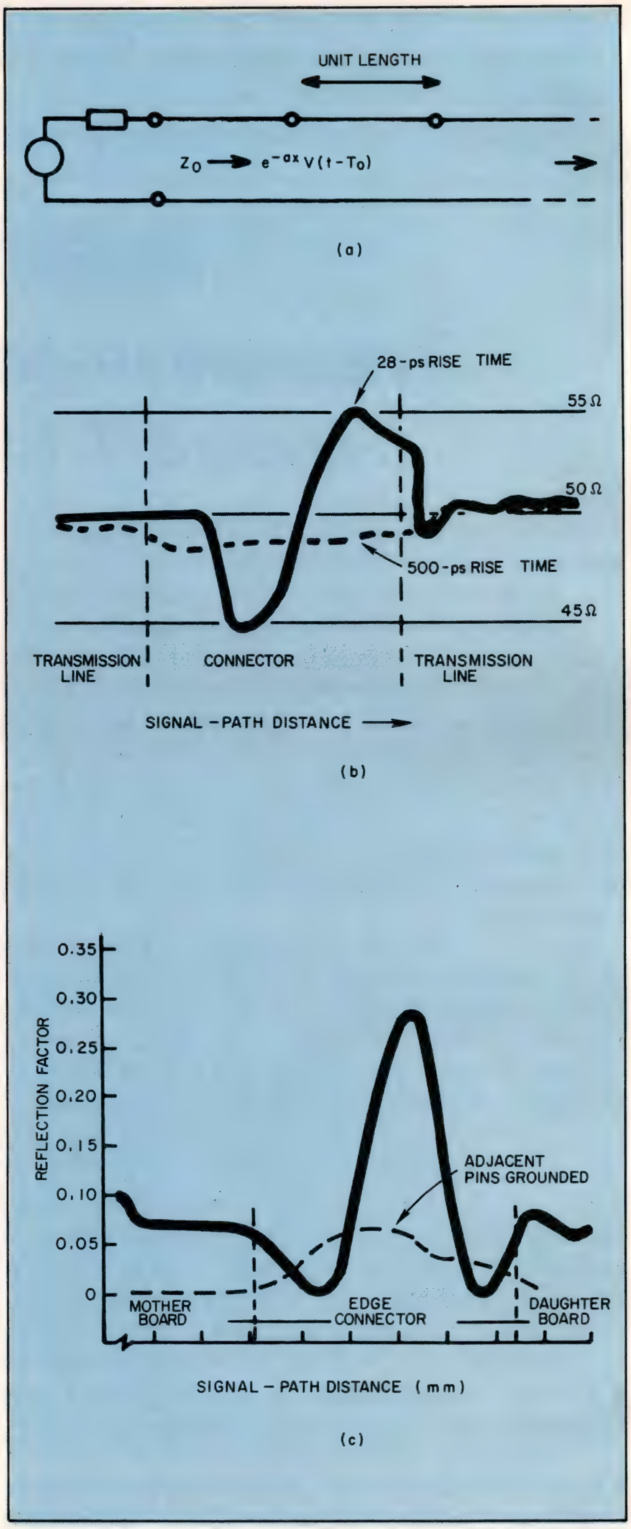
Digital pulses are attenuated in transmission lines by both the shunt capacitance (and leakage, generally negligible) of the dielectric and the series resistance of the conductor. The resistive losses are aggravated by skin effect, but this varies only as the square root of frequency. On the other hand, dielectric attenuation varies directly as frequency, which means that at a frequency of 500 MHz, the dielectric loss can represent as much as one-quarter the total attentuation, and one-third at 1 GHz.

Total attenuation in an open line to about 1 GHz can be calculated (approximately) in dB as follows:

$$\alpha = kF^{1/2},$$

where α is the attenuation per unit line length, F is the frequency and k is a proportionality constant governed by the line's conductor size, permeability and conductivity.

Signal reflections, which generally cause more serious problems inside electronic circuits than attenuation, occur whenever a signal encounters a discontinuity (sudden change) in impedance. Discontinuities can appear at interfaces with connectors, circuit boards or components—or, indeed, with or in transmission lines. For example, a discontinuity between a mother and a daughter board can be introduced by an edge connector (Fig. 2b), but simply grounding pins on both sides of the signal pin can



2. Take the characteristic impedance of a transmission line (a) into consideration when interconnecting high-speed digital circuits. For example, nearly 30% reflectivity is exhibited by an edge connector to a 0.15-ns pulse; however, it can be reduced to 5% by proper capacitor-impedance compensation (b). In addition, note the much greater discontinuity effect a 28-ps rise-time signal has over that of a 500-ps rise-time signal when the signals encounter a connector in a transmission line (c).

dramatically reduce the energy reflection factor.

Since discontinuities between an IC and a board (as in Fig. 2b) generally occur over short distances relative to the critical wavelength, they are not nearly as troublesome as those between two boards separated by a greater distance. The longer the distance occupied by the mismatch, the greater the amount of reflected energy and hence the greater the distortion. For distances corresponding to less than half a wavelength of the impressed signal, mismatches tend to average out.

Trouble is, at frequencies above 100 MHz (with rise times of about 3 ns and less), the signal wavelength is short enough so that connectors become an appreciable part of the wavelength—and an impedance mismatch can seriously degrade a signal. Thus, a connector mismatch is more severe at a pulse rise time of 28 ps than it is at 500 ps (Fig. 2c). For such fast rise times, even conductive circuit-board pathways must be viewed as a part of the transmission line and should be impedance-matched.

Most PC-board connectors (such as card-edge units and flat, flexible cable) can be used at rise times down to about 4 ns—provided a particular arrangement does not present too great an impedance mismatch and the signal path is less than 1 in. long. For example, a 22-pin edge connector handling 21 signal lines but served by only a single ground line at one end is an unsatisfactory arrangement for fast pulses. Signal lines close to the ground pin will have a reasonably low impedance (close to 100 Ω), but lines furthest from the ground will present a much higher impedance (perhaps 1000 Ω). Moreover, all the ground currents will travel a common path and have a large common inductance, which can couple a substantial amount of crosstalk among the lines. Signal lines furthest from the ground line could easily encounter a 50% coupling-factor problem.

One way to make a significant improvement is simply to move the ground line to the center of the connector. But a better solution is to use more contacts as grounds. Best performance, however, results from an alternate signal-ground-signal-ground pattern. Since this arrangement may need more contacts than are usually available, this method is generally not considered except for very critical applications. Most board-edge connectors exhibit a characteristic impedance reasonably close to 75 Ω if surrounding pins are grounded. To obtain a 50-Ω match, compensating capacitors must be added to the circuit board.

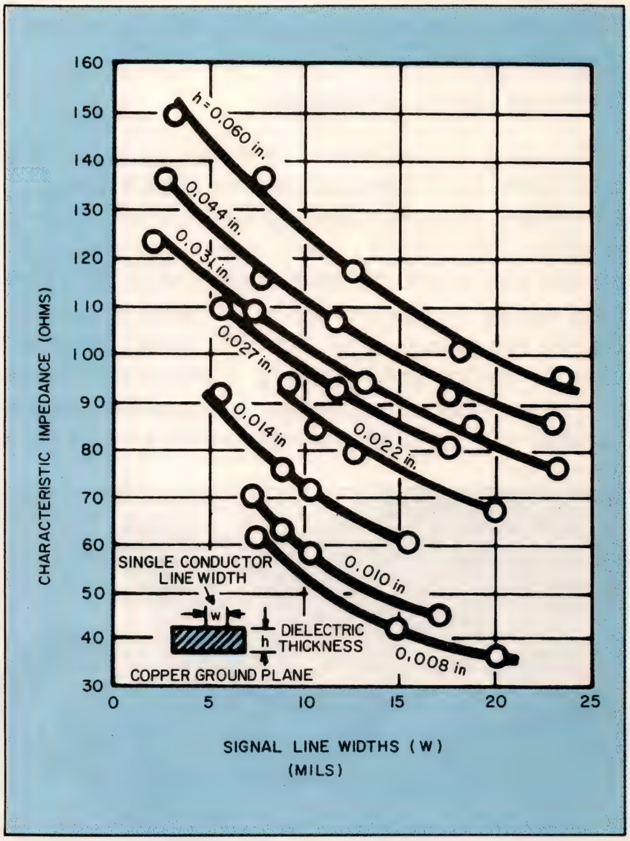
The connector inductance, which increases the characteristic impedance, can be partially compensated by a properly placed lumped capacitance, but this is limited to frequencies below 1 GHz. For best results, compensation should be performed experimentally using time-domain reflectometry techniques[1] that can handle rise times of less than a picosecond at about 12 GHz.

Of course, reflection problems can be reduced by decreasing the length of interconnections: Merely pack the components more tightly. Problem is, such an approach raises the likelihood of crosstalk interference.

Crosstalk not welcome

Crosstalk—unwanted signal coupling—between lines, cables and circuits can, when joined by other background noise, mask desired signals and falsely trigger flip-flops, counters and other logic elements.

Capacitance in closely spaced circuits generally is the primary coupling mechanism: Close interconnections have high mutual capacitance, which carry more energy as the frequency rises. About 90% of



3. Microstrip construction is an excellent way to control interconnection impedances on circuit boards. The plot provides the characteristic impedance (Z_0) of signal conductors made of 2-oz, 0.0028-in.-thick copper foil having various widths (W), when the conductors are laminated on conventional epoxy-glass (e_r between 5 and 6) boards of various thicknesses.

induced crosstalk is from immediately adjacent lines. Thus, in PC boards, crosstalk can be reduced by providing wide spacing between signal-conductor traces and by placing the conductors as close to the ground plane as possible.

Naturally, where possible, total shielding is best for minimizing signal degradation from crosstalk and other noise coupling. Fully shielded systems such as coaxial cables completely enclose the signal line within a metallic ground. However, planar wiring, as on PC boards and flat cables, must resort to a pattern of interleaved signal and ground conductors—all the while maintaining a desired characteristic impedance—to achieve a measure of shielding. Unfortunately, not all the dielectric paths from one signal line to another can be completely blocked. In coaxial cable, virtually all unwanted signals are shunted to earth by the shielding; in controlled-impedance planar/wiring, a lesser but adequate level of crosstalk immunity can usually be achieved at a much lower cost.[2]

Microstrip controls impedance

One form of controlled-impedance planar wiring is microstrip, a transmission line implemented on a PC board of known dielectric constant and uniform thickness. The board's lower side has a conductive ground plane, and the upper side carries the signal lines etched in selected widths for different characteristic impedances (Fig. 3).[3,4] The signal lines kept close to the ground help keep the crosstalk down.

Another way of controlling a characteristic impedance and reducing crosstalk is with twisted pairs—simply two insulated wires twisted together. Uncontrolled, a single wire connecting two points may present a characteristic impedance of several thousand ohms and provide a severe mismatch. However, a twisted pair made with just standard plastic hookup wire can have a controlled characteristic impedance of about 100 Ω; made with thinly insulated Formvar wire, the twisted pair would have a characteristic impedance of about 50 Ω.

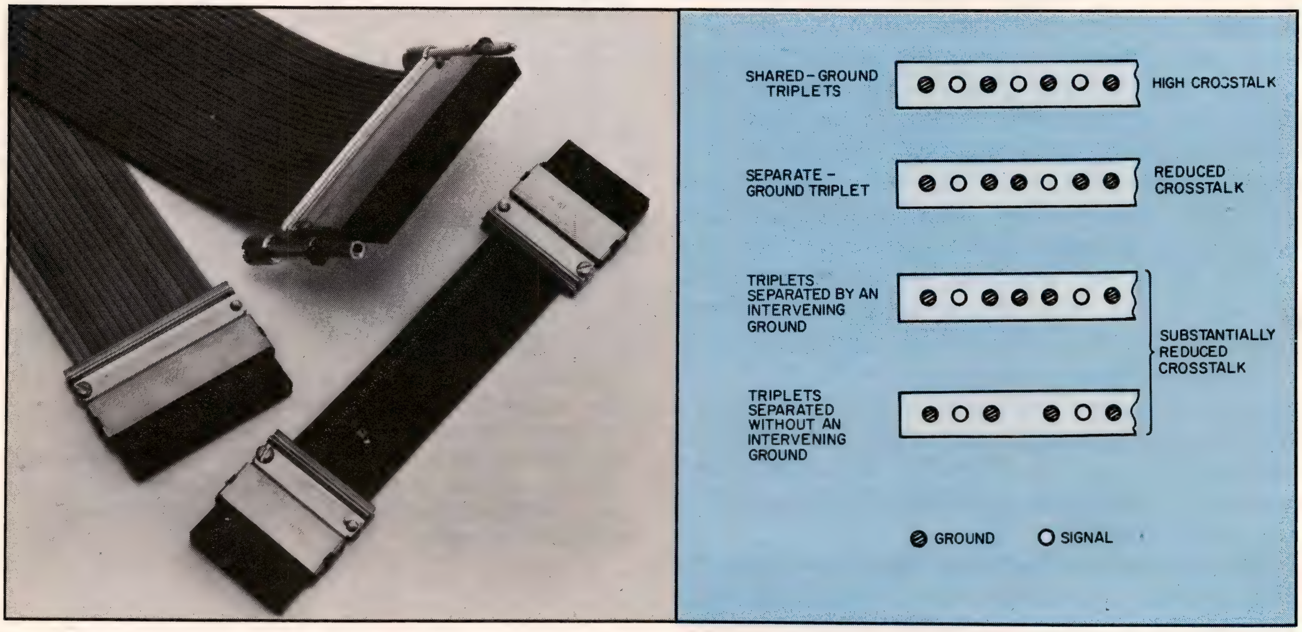
Keep the twisted wires in intimate contact to balance out common-mode pickup (or radiation), and the pitch (number of twists per inch) will have a negligible effect upon the impedance. (But the propagation delay is affected: The more twists per foot, the longer the path and hence the greater the delay.) Characteristic impedances of twisted pairs stay within about 8% in a cable bundle. In most such cables, with a controlled pitch designed for mass termination, the nominal propagation delay ranges from about 1.2 to 1.6 ns/ft and propagation-delay variations are held to within about 5% of the nominal.

The standard two-wire transmission-line equation provides an approximate way to calculate the characteristic impedance of a twisted pair:

$$Z_0 = \frac{120}{(e_r)^{1/2}} \text{Ln}\left(\frac{2D}{d}\right),$$

where e_r is the dielectric constant of the insulation, D is the center-to-center distance between wire centers and d is the diameter of the conductors.

Happily, twisted pairs are surprisingly immune to noise pickup because pickup in one wire tends to


SHARED-GROUND TRIPLETS
HIGH CROSSTALK
SEPARATE-GROUND TRIPLET
REDUCED CROSSTALK
TRIPLETS SEPARATED BY AN INTERVENING GROUND
TRIPLETS SEPARATED WITHOUT AN INTERVENING GROUND
SUBSTANTIALLY REDUCED CROSSTALK
GROUND
SIGNAL

4. In flat cables (left), crosstalk can be controlled by separating the signal-carrying wires either with grounded wires or just space (right). The more grounded wires used or the further the signal wires are separated, the lower the crosstalk.

cancel the pickup in the other wire. Nevertheless, cable-to-cable crosstalk between adjoining twisted-pair cables can be as high as 30% when signal rise times approach the propagation delay of the cable.

Twisted pairs generally provide adequate noise immunity at low frequencies, especially where the pickup is from remote sources—distances that are large relative to the pitch length. Performance in twisted-pair bundles can be improved by twisting the pairs with each other. Also, within a bundle, the pitches should be multiples of two; for example, a bundle of four sets of twisted pairs could be wound with 2, 4, 8 and 16 twists per foot. Unfortunately, fast-rise-time systems can experience problems from the different propagation delays caused by the different winding pitches.

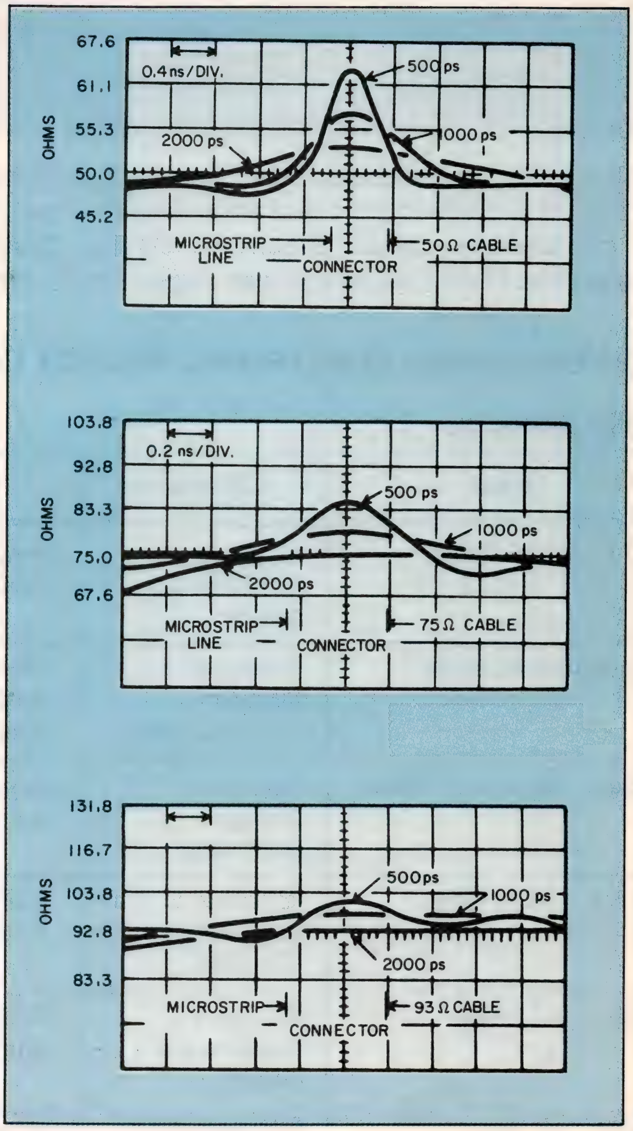
Flat cables have advantages

Flat cables, on the other hand, are mechanically neater and often more convenient and economical to install in electronic assemblies. Flat cables—which have a planar cross-sectional geometry—are made with either flat or round conductors. Dielectric media range from relatively inexpensive polyvinyl chloride (PVC) to more expensive Teflons. The single-unit construction of flat cable can greatly reduce handling costs, and the fixed geometry of the conductors can reduce wiring errors and provide more closely controlled impedances than twisted pairs.

Many flat-cable configurations are available. In the simplest flat transmission cable, a signal conductor shares ground wires with the adjoining signal wires (Fig. 4). The conductors lie side-by-side in a continuous ribbon-like strip—a configuration that lends itself to easy mass termination and high-density applications. Crosstalk can be reduced further by employing separate grounds, and still further by adding an intervening ground or increasing the spacing.

In a typical round-wire, flat-cable configuration with one ground wire between each signal path, the crosstalk isolation can be as low as 1.5%; with two grounds between signal lines, the isolation can be less than 1%.

Round-conductor flat cable offers a wider range of impedances, from approximately 50 to 200 Ω. Flat-conductor cables cannot achieve nominal impedances below 90 Ω, because the required close wire spacing is difficult to maintain.



5. Coaxial ribbon cable produces very little impedance discontinuity at both connector/microstrip and connector/cable interfaces. Cables are available with 50, 75 or 93-Ω impedances.

Another consideration is skin effect. For signal frequencies exceeding 1 GHz, a greater portion of the total current is carried at the wire's surface. In such cases, flat-conductor cable provides about twice the surface area of an equivalently-gauged round wire. The greater surface area also enhances cooling. Thus, for a given current requirement, designers can select a flat conductor-wire gauge that is two to three gauges smaller than would be required for a round-conductor flat cable.□

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3. Porter, J., "Compute Coupled-Microstrip Line Configurations," ELECTRONIC DESIGN, Jan. 4, 1977, p. 116.

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Aug. 18-20, 1980	Telecom/ Design Chicago 1980	O'Hare Airport Area	For Telecommunications IC Users
Sept. 29-Oct. 1, 1980	Telecom/ Design East 1980	Woburn, MA Ramada Inn	For Telecommunications IC Users
Oct. 13-17, 1980	IC Users Conference (Central)	Dallas/The Hilton LBJ	Oct. 13-14: Linear ICs Oct. 15-17: Microprocessors
Nov. 3-7, 1980	IC Users Conference (West)	Sunnyvale, CA Hilton Inn	Nov. 3-4: Linear ICs Nov. 5-7: Microprocessors
Nov. 11, 1980	Engineering Employment Managers Conference	Sunnyvale, CA Hilton Inn	Theme: "The shortage of engineers — What do we do now?"

Planned for Early, 1981

Probable Date	Conference	Probable Location	Description
January, 1981	Leisure-Time Electronics	Las Vegas	For Designers of Electronic Games and Consumer Electronics Products
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A Solid State Line Card Using Four LSI Components. Discussion of CODEC filter TSAC (time slot assigner circuit) and SLIC (subscriber loop interface circuit). The characteristics and features of the components will be discussed in the context of their aggregate use in a digital switch. Topics covered will be voice frequency performance, common control implementation and supervision methods.Bob Karasch, product marketing, telecom, Motorola Semiconductor, Austin, TX.

Designing With Low-Power Monolithic CODECs and PCM Filters for Use in D-3, Channel Bank and PBX Applications. This talk will describe the interface between the two-wire telephone analog input and the digital switching network. Russell Leath, telecom applications engineer, Mostek, Carrollton, TX.

A New Generation of Loop Disconnect Dialer Circuits. The evolution of integrated circuits for loop disconnect dialing has occured in discrete steps following the earlier high-voltage PMOS circuits. The present trend is to produce circuits that don't simply emulate the rotary dial but that offer feature sets that are only available from an integrated circuit. Concurrent with this trend is the drive to reduce systems costs, both by reducing IC costs and by minimizing external interface components. A new family of dialer circuits, designated the DF 820 through DF 823, currently in design will implement these characteristics. This discussion will detail the IC design philosophy and system implementation. Barry Boulton, marketing manager for telecom, Siliconix, Santa Clara, CA.

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Using LSI Building Blocks to Design Shared CODECs. By using bipolar LSI devices such as the MUX-88, DMUX-88, SMP-81, REF-82, COMDAC-86/7/8/9, OP-86, systems of up to 24 channels can be built at costs under $5 per channel excluding filters. Applications include broadband channel banks (high-quality music channels) private automatic branch exchanges (PABX), D-3 channel banks, PCM concentrators and central office equipment. Tac Berry, Precision Monolithics, Santa Clara, CA.

Improved Single Chip CODEC and PCM Filter Lead to Better Applications Performance. The only single chip CODEC with microcomputer interface now has improved half-channel specs. This combined with improved filter specifications results in a better overall system performance while also reducing power dissipation and improving power supply rejection. Tsung Mok, senior design engineer, telecom and Wayne Baxter, senior design engineer, telcom, Intel, Santa Clara, CA.

Time Slot Assignment and Line Card Control From a Microprocessor Bus. Several new microprocessor peripheral products dedicated to time slot assignment and line card control functions will be discussed. A possible bus architecture for implementing a digital switch will be shown. Neil Wellenstein, manager communications systems, strategic marketing, Motorola Semiconductor, Phoenix, AZ.

New Switched Capacitor PCM Filter Set. A new monolithic switched capacitor filter chip set has been designed for applications in PCM channel banks and digital central office and PABX switching equipment. These chips provide a higher level of performance than has been available with earlier designs, In addition, a wider range of application is made possible by a phased-lock-loop on the chip for clock generation. Features of the new chip set are discussed along with a block diagram description, major specifications, applications information and a typical design example. Gary Rothrock, applications manager for telecom, Siliconix, Santa Clara, CA.

ICs for PCM Repeaters. LSI chips didn't just replace discrete semiconductor devices as the active elements of T-1 PCM repeaters. They provided additional functions such as on-chip regulators, shut-down circuits, and ALBO. Now, more functions such as multiple ALBO are coming. Guido Pastorino, Precision Monolithics, Santa Clara, CA.

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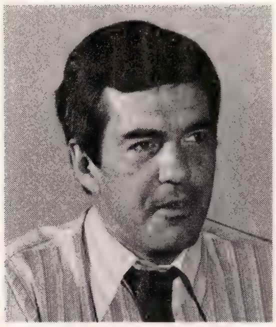

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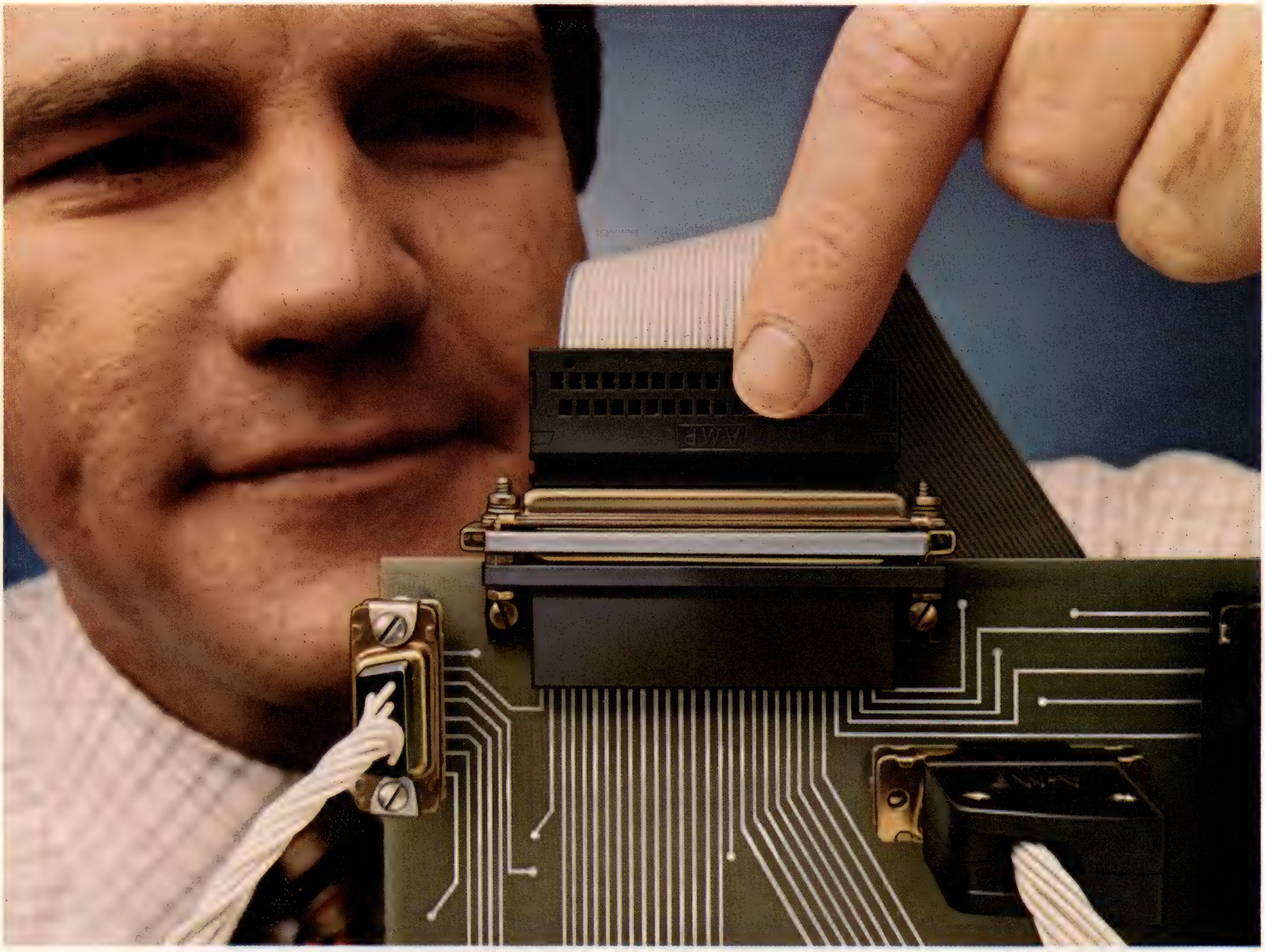

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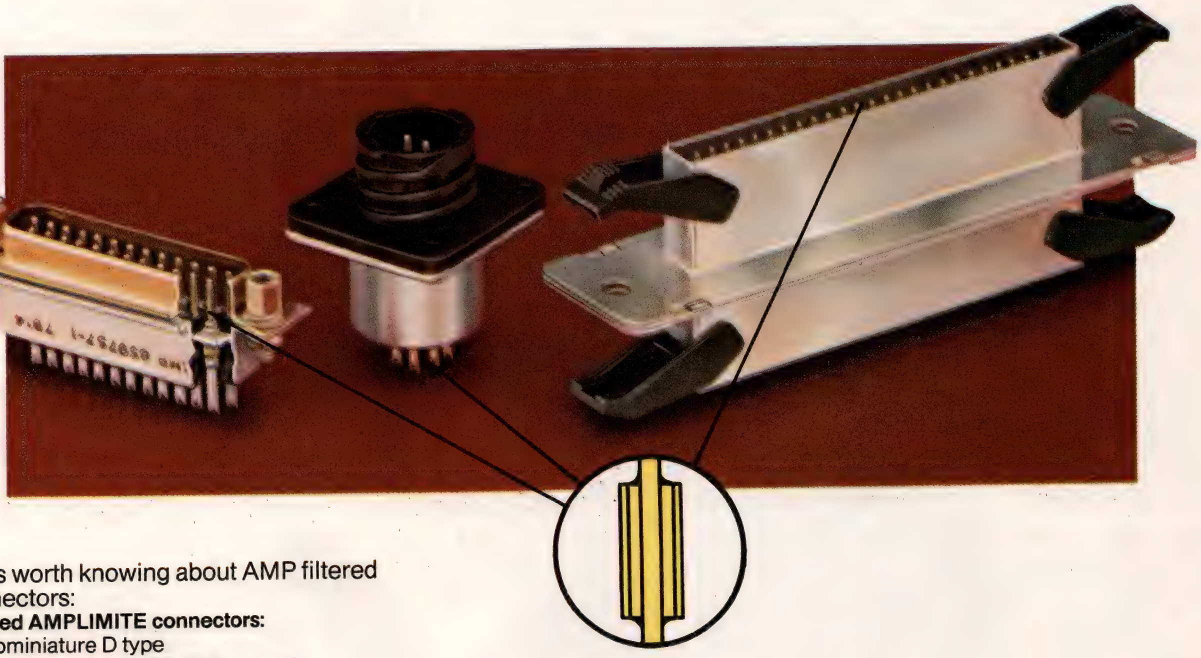

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CIRCLE 38

DVM Downtime

How often do you send your DVMs to the cal lab? Every three months? Every month? Or are you making ultra-precision measurements that require weekly or daily calibration? Now, how long do you have to wait to get them back? A few hours? A few days? A few weeks? How much time and money could you save if it took fifteen minutes or less to calibrate a DVM. Not a zeroing out, but a complete calibration of every range and every function including AC high frequency and input bias current.

Well, that's what you can do with Datron's AUTOCAL.

The Datron Autocal covers every range and every function without plug-in boards or separate modules. Complete calibration of AC, DC, ohms and current on every range can be carried out in a few minutes from the front panel. Even source errors due to input bias current are taken into account by the Datron Autocal. No adjustment pots to tweek, no disassembly. In fact, you can operate your Datron DVM for five years or more without removing the covers.

Calibration of each range/function takes only a few seconds. To calibrate the 10 volt DC range, for example, press the 10 V "range" button, short the input terminal and press the "zero" button. This updates the zero calibration reference. Remove the short, apply 10 volts and hit the "gain" key. That's all it takes. And, because the calibration is not interactive, none of the other range/functions are effected. If the 10 V DC range is the only one requiring calibration, the DVM can be put back into operation immediately. Datron's Autocal let's you calibrate any or all of the range/functions as required.

Incidentally, the calibration mode is "enabled" by a key operated switch in the rear panel. The key is normally kept by a calibration or supervisory engineer to prevent unauthorized or accidental access to the calibration memory.

Another feature of Datron's Autocal is its ability to operate on the IEEE bus. In conjunction with a bus compatible calibrator, your Datron DVM can be calibrated remotely and in situ. In systems use, where DVM downtime can also mean system downtime, this can reduce to fifteen minutes or less what could otherwise take a minimum of several hours and a maximum of several days.

There are a lot of other time and money saving features of Datron DVMs such as automatic self-test, error read-out and computing capability plus a comprehensive *five year warranty* and free annual calibration for five years. These features and specifications are covered in detail in our new literature. Write for it. It's free.

datron
INSTRUMENTS INCORPORATED

CIRCLE 39

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Conductive elastomers can be the solutions to many problems—but not understanding their chemical, electrical and mechanical properties could lead to new problems.

Conductive-elastomer applications abound

Conductive elastomers are replacing conventional products as rf shields, press-fit connectors and switches in all sectors of the electronics world: military, aerospace, commercial and consumer. However, designers looking to get involved with conductive elastomers and their many possible applications could be in for a rough time if they don't understand the chemical, electrical and mechanical properties they'll be dealing with—and the potential pitfalls.

Conductive elastomers take many forms, but the most dominant material used today is silicone "rubber" that has been mixed with an electrically (and sometimes thermally) conductive filler. The silicone resins in the conductive-rubber materials are basically electrically nonconductive. As insulators, they are readily formulated to provide very good physical characteristics. Fillers such as silver, carbon, stainless steel, monel, aluminum and nickel must be added to make the resin conductive.

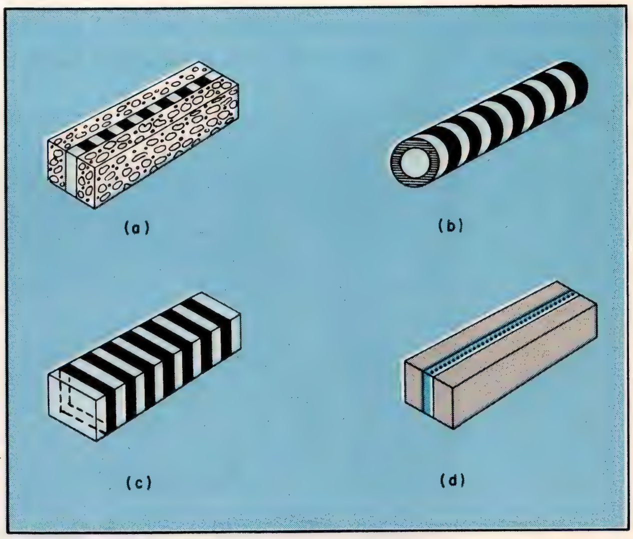
However, adding these fillers can easily destroy the good physical properties of the basic silicone-resin materials by:

- Increasing the hardness
- Increasing the compression set—material fails to recover dimension fully after being compressed
- Reducing the tear strength.

On top of all that, silicone-oil leakage from the resin, in time, could negate the conductivity of the filler by insulating the elastomer from the electrodes it should be interconnecting.

In connector applications, the elastomer's hardness rating, or durometer, determines the number of pounds of force necessary to compress the material to make a good electrical contact (normally 3% to 20% compression). However, many suppliers measure the durometer only before filler is added, which means that the finished product could end up being two or three times harder than specified and requiring much more pressure than anticipated to make a good contact.

One problem related to the hardness is the little-known fact that solid-silicone rubber, like water, is not compressible; it "compresses" only when there is empty space around it into which the material can



1. Sponge-rubber (a) or hollow-cored (b) elastomeric materials (shown with alternate conducting and insulating layers) prove superior to solid-rubber arrangements (c), even ones with wire inserts (d), because the spongy material needs much less force to compress and form more-effective air-tight connections.

Harry Stern, President
Conductive Rubber Technology
1230 Coast Village Circle, Santa Barbara, CA 93108

"flow" when force is applied. Some engineers learn this fact the hard way—when PC boards bend or components crack trying to make good contact—because the material is confined without flow room.

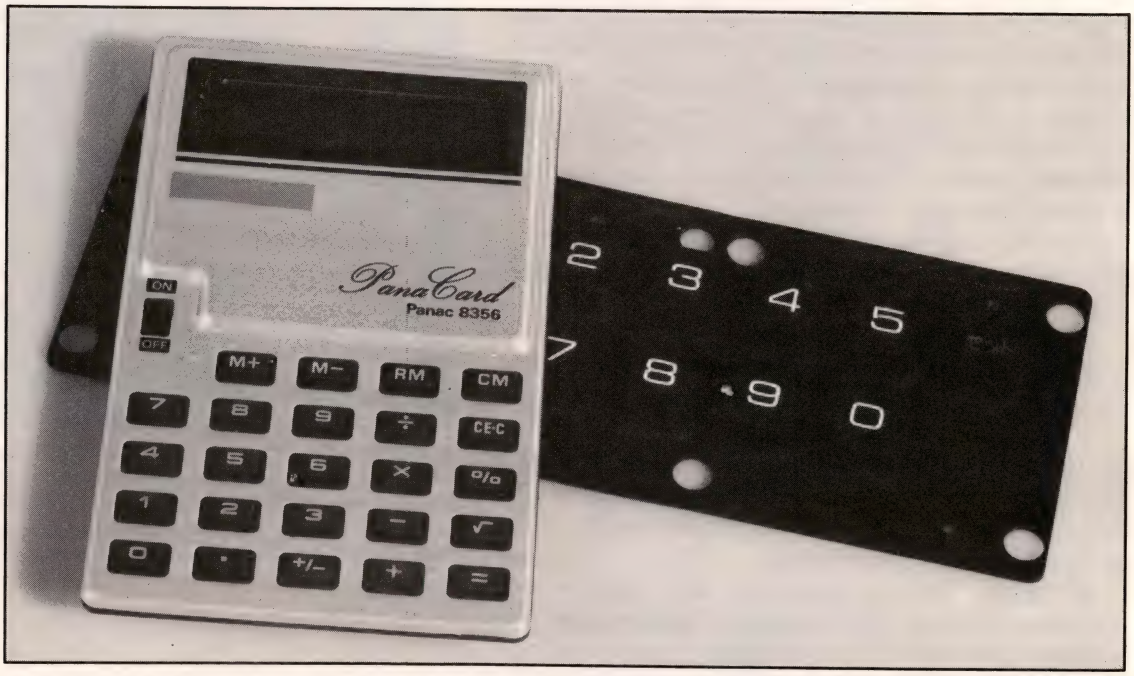
A sponge-rubber or hollow-cored solid-rubber material (Fig. 1) is more suitable. Such materials need just one-fourth to one-fifth the force of a solid-rubber part to compress. A solid-rubber part is not advised particularly when the contact-surface length is larger than 1 in.

Compression set is another trap. Generally, when a solid-elastomer part is compressed 3 to 5% over a period of time, it will recover to only 80% after the force is removed. Even connectors made of hollow-cored solid materials are not recommended, especially when repeated compressions are anticipated and the initial compressions exceed 25%. Indeed, wire-impregnated, solid-rubber connectors (another way to make elastomers conductive) should never be used more than one time: When equipment is taken apart and then reassembled, the connectors should be replaced. Once again, a sponge product offers a solution: Sponge material can take a 20% compression and still allow reassembly, because it takes a negligible set.

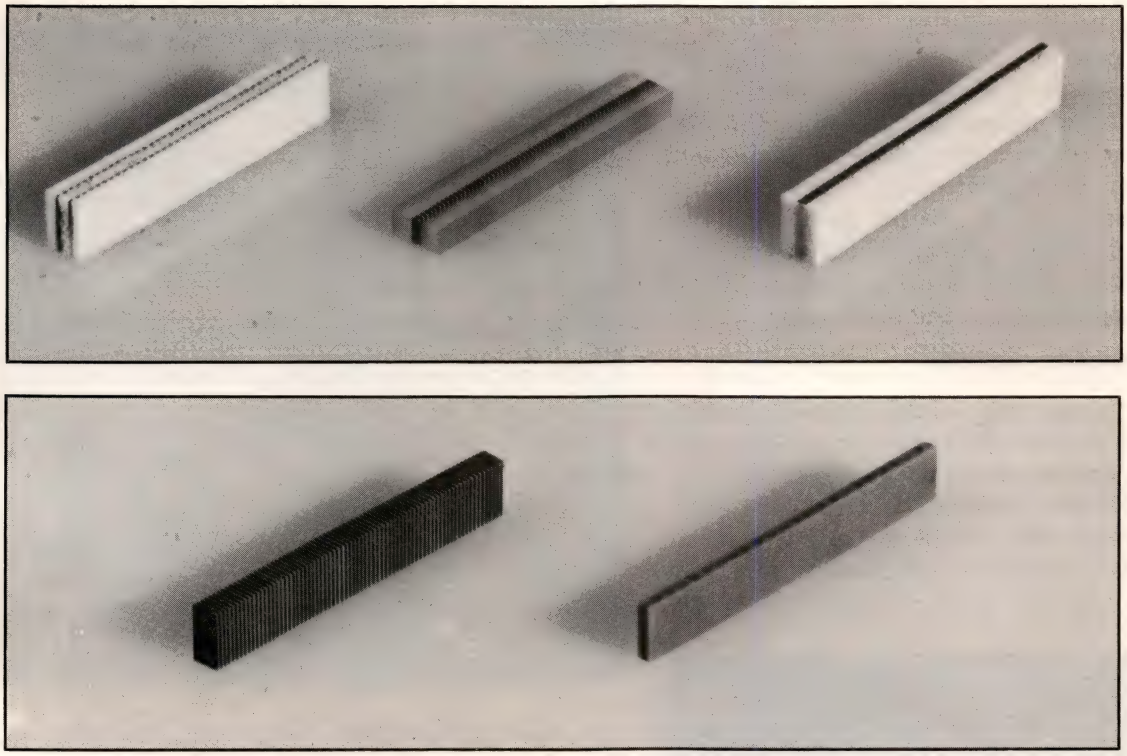
But perhaps the worst problem is that some of the electrically conductive combinations are not stable: The material, although it may be highly conductive initially, often gradually increases its resistance as it ages. Many conductive-elastomer users discover this too late. At this point, connectors from only one company in Japan do not increase resistance with time when conducting current; instead, resistance actually decreases. The solution? A proprietary silicone-resin formulation that does not bleed silicone oil—even under pressure—either at elevated temperatures or as the formulation ages.

All other conductive-elastomer connector and switch companies purchase commercial grades of silicone resins that, unfortunately, do bleed silicone oil. The oil coats conductive surfaces with an insulating barrier and prevents electrical conduction. A large microcircuit manufacturer recently discovered this problem in the connectors of a burn-in facility used to age microcircuits. Though the connector supplier specified that the layered conductive elastomer used was stable to 260 C, in fact, an oily residue bled out of the connector at just 180 C. As a result, an initial resistance of 500 Ω quickly rose to more than 10,000 Ω after only a few hours—a specification that was not found in the supplier's catalog.

Of course, the oil-leakage problem is equally damaging for switches. How damaging? Some suppliers guarantee only 100,000 switching cycles—without silicone oil leaking onto the contacts, 10-million



2. Keyboard switches made of the proper elastomer formulation can readily attain a life of 10-million contact cycles at low cost by avoiding oil-leakage problems.



3. Elastomeric connectors should have a finer trace pitch (bottom) than the electrodes they interconnect to avoid alignment problems and cross-connections. In addition, short-circuit problems can be avoided by using connectors with insulated sides (top).

cycles would be a practical target for elastomer switches (Fig. 2).

Mechanical properties—important

Mechanical properties of a particular contact or connector are as important as the oil-leakage characteristic. Accordingly, design engineers should carefully examine the following mechanical specifications (see Table):

- Height, thickness and other dimensional tolerances
- Trace-alignment accuracy (skew) in connector-conductor layers
- Insulation protection
- Cut squareness
- Fabrication technique.

The most critical dimension of a press-fit connector is the height of the interfacing elastomeric conductor material—the distance between the electrodes to be connected. The elastomer material must compress at least 5% (10% is better), so dimensional tolerances can become tight. For parts thicker than 0.040 in., the best tolerance for height offered by any manufacturer is ±0.004 in.; for under 0.040 in., it's normally +0.008, −0.000 in.

Most elastomeric-connector interface materials should have a finer trace pitch for the spacing between conducting layers than the electrodes they connect—at least three times finer (Fig. 3, bottom). As a result, aligning the traces on the connector with the electrodes will be no problem: With the electrodes carefully aligned, the interface elastomeric material is then simply placed between them.

However, the best results are obtained when the conductive traces are truly perpendicular to the electrode surfaces. Problem is, some connector manufacturers cannot keep the conductor traces in straight lines—a defect called skew. In extreme cases, skew can cause cross-connections (short-circuits). The skew in an interface connector can be rather large: According to one manufacturer's catalog, a connector 0.08 in. wide and 0.3 in. high can have as much as a 0.015-in. skew. Unfortunately, many equipment manufacturers are finding out about skew after installing many defective connectors. The solution: Check skew before installing; or, better still, buy connectors without skew.

Another way to avoid trouble is to purchase an elastomeric connector that is insulated along the nonconducting surfaces, especially if it costs no more (Fig. 3, top). The insulating materials should be softer then the conductive elements to allow the flow previously explained. Also, the insulated sides act as a safeguard against shorts, particularly in crowded locations. And in the case of silver-filled elastomers, the insulation helps prevent silver migration and galvanic corrosion.

Silver filler produces a low-resistance product, but it has problems. For example, silver migration can be demonstrated by measuring the change of insulation resistance between two adjacent gold-plated electrodes that are insulated from each other. A silver-filled elastomer is pressed across the two electrodes, each 0.04 in. wide and separated on a PC board by 0.02 in. of the board insulation. About 250 V dc is applied across the electrodes.

Temperature speeds migration

Raising the temperature of this assembly to 60 C and increasing the humidity to 95% for 240 hours will accelerate the process. The insulation resistance between the electrodes starts at about $2 \times 10^{12}\ \Omega$, and if migration takes place, drops to about $2 \times 10^{6}\ \Omega$.

Almost all solid-elastomer, silver-filled connectors exhibit such a migration problem, except for a newly developed, silver-filled sponge connector (Fig. 4). Closed sponge cells at the electrode interfaces prevent exposed silver surfaces (as exists in solid-elastomer connectors), which keeps migration from starting at these surfaces.

Recommended tolerances

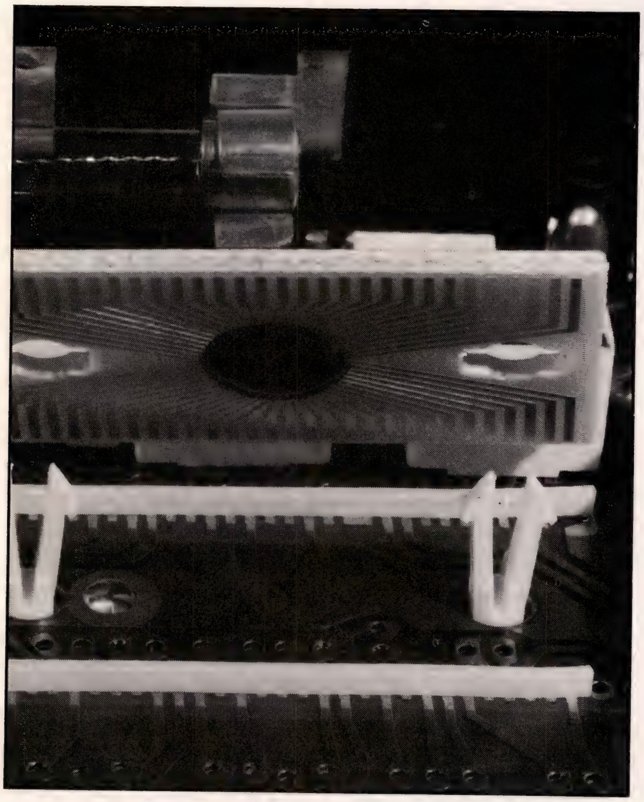
For conductive-elastomer connectors

Height tolerance: ±.004 in.
Length tolerance: ±.015 in.
Width tolerance: ±.006 in.
Pitch: 3 × electrode pitch
Tolerances: ±.004 in. @ 65/in.
±.002 in. @ 200/in.
Skew (total): none

For switches

Critical dimension tolerance: ±.003 in.
Force: for ±20% compression
Contact resistance: generally about 200 to 500 Ω
Life required: 100,000 to 15-million cycles
Flash specifications: ±.003 in.
Abrasion resistance (to imprinting): 3-million cycles with a 200-g force-wiping test

Note: No foreign matter on surfaces (dirt, glue, oil, etc.). Specify required squareness and maximum force for desired compression, temperature, current and resistance.



4. A newly developed sponge-supported connector is silver-filled to attain low resistance. Nevertheless, it does not exhibit the silver-migration problems of most other silver-filler types, and thanks to the gas-tight seal the elastomeric sponge material also prevents contact corrosion.

Also, the sponge material forms gas-tight seals, which alleviates the galvanic-corrosion problem. When a more noble (less chemically active) metal touches a less noble metal in the presence of humidity, a battery circuit is formed. The result is galvanic corrosion of the less noble material, which occurs when silver-filled connectors (silver is a noble metal) contact indium-oxide or tin-lead electrodes. The gas-tight seal and closed-cell structure of the sponge-material heads off corrosion by preventing moisture from reaching the silver-electrode interface. Moreover, the closed-cell sponge has no exposed silver surface that humidity can attack.

Silver migration and galvanic corrosion are not the only things to watch out for. Be careful of temperature specs and circuit shorts.

Most suppliers of silver-filled elastomers rate their products at room temperature, which can be misleading. Increased temperature reduces current flow in some products, even when temperature is below a specified upper limit. Current rating and temperature are tied together and must be considered together—such as 1 A at 25 C. But don't depend on supplier ratings—test a particular connector or switch before using it in a circuit.

And watch out when silver-filled elastomers come in the form of silver-plated beads—these tend to drop silver particles from cut edges into a customer's circuits. Look at elastomers under magnification, or rub the cut surface of the material over a piece of plain white paper. If there are small beads, be warned: The best low-resistance connectors contain no silver beads, but are made with microscopic, suspended silver powder.

Check under magnification

A magnifying glass can check not only for silver-plated beads but also the general quality level of a supplier. Look for ragged cut edges, irregular or shorted conductive traces, glue-on conductive surfaces, out-of-square surfaces, skewed lines and foreign matter. Also, test a connector's resistance after it has been operated under a load at between 60 and 100 C.

Even with a perfect checkout, no matter who the supplier is, here are some basic rules to help with a successful conductive-elastomer design:

- Use the widest possible connector to get the best gas-tight seal possible. Connectors limited to widths of 0.030 in. or less will not seal adequately and allow electrode corrosion. Width should be at least 0.040 in.; 0.080 in. is even better.
- Specify the softest connector material available. Solid-silicone connectors, which need more than 2 lb/in. to compress 15%, should not be used (unless with gold-plated contacts); sponge products are best.
- Clean tin/lead contacts (when used instead of gold) before assembly. Sulfur fumes can corrode tin/lead traces and cause open contacts.

Problems with tin/lead contacts can be eliminated with gold plating—expensive but best where the cost can be tolerated. In laboratory tests, a gas-tight seal can be made between an elastomeric connector and bare tin/lead contacts that produces no increase in resistance, even under adverse atmospheric conditions. But duplicating these results in production is another matter and difficult to achieve.

Nevertheless, tin/lead traces are used successfully in low-cost, limited-life electronic games, toys and even calculators and clocks. However, in important industrial applications or in high-cost instruments, gold-plated contacts are recommended for the elastomeric interface material to reduce the possibility of failure. Fortunately, expense can be kept low, because a very thin layer of gold will suffice: The gold experiences no wear in either connector or switch application. Just 0.3 μm of plated gold over 3 μm of plated nickel and situated on 35 μm of copper will produce excellent results.□

How useful?	**Circle No.**
Immediate design application	550
Within the next year	551
Not applicable	552

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Stability·
Repeatability·
Low Noise·
Linearity·
Accuracy·

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CIRCLE 40

16 BIT WAY
2732A
64K
8086
WAIT
DON'T
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No Waiting

Introducing the Intel® 2732A EPROM. Now you can design 16-bit microcomputer systems without delays.

Now get all the performance you're paying for from your microprocessor designs with Intel's new 2732A EPROM. For 16-bit microprocessor systems, 2732A EPROMs deliver both the high speed (250ns) and high density (32K) solution. No other 32K EPROM on the market comes close.

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By designing with the 2732A today, you're actually designing with the standard of tomorrow. The 2732A is a product of Intel's proven, reliable fourth generation EPROM technology, HMOS-E, and the first to come in a family of dense, high speed EPROMs.

HMOS-E technology means that we'll be able to incorporate high performance features, like increased density, into future EPROMs, without affecting their speed or power characteristics. The 2732A is your first step towards a degree of flexibility in memory design never before available.

JEDEC approved pinout

You can start designing for tomorrow now because the 2732A's pinout conforms to the approved JEDEC committee standard for byte-wide memories from 16K bits to 256K bits. So you can upgrade from a 2732A without changing your design or board layout. And you won't have to sacrifice features like 2-line control—a must in high-speed memories for avoiding bus contention problems.

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Like all our EPROMs, your 2732As are put through rigid quality control tests to insure they'll retain their programs and programmability for years to come.

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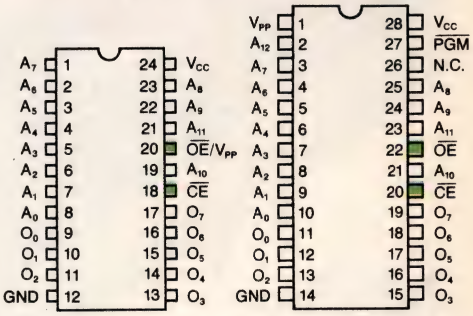
2732A Pin Configuration

64K Pin Configuration

The 24-pin 2732A pinout conforms to the 28-pin JEDEC committee approved design for byte-wide memories. By using 28-pin sockets, there's no need for delays in upgrading to the 64K, 128K, or 256K EPROMS of the future.

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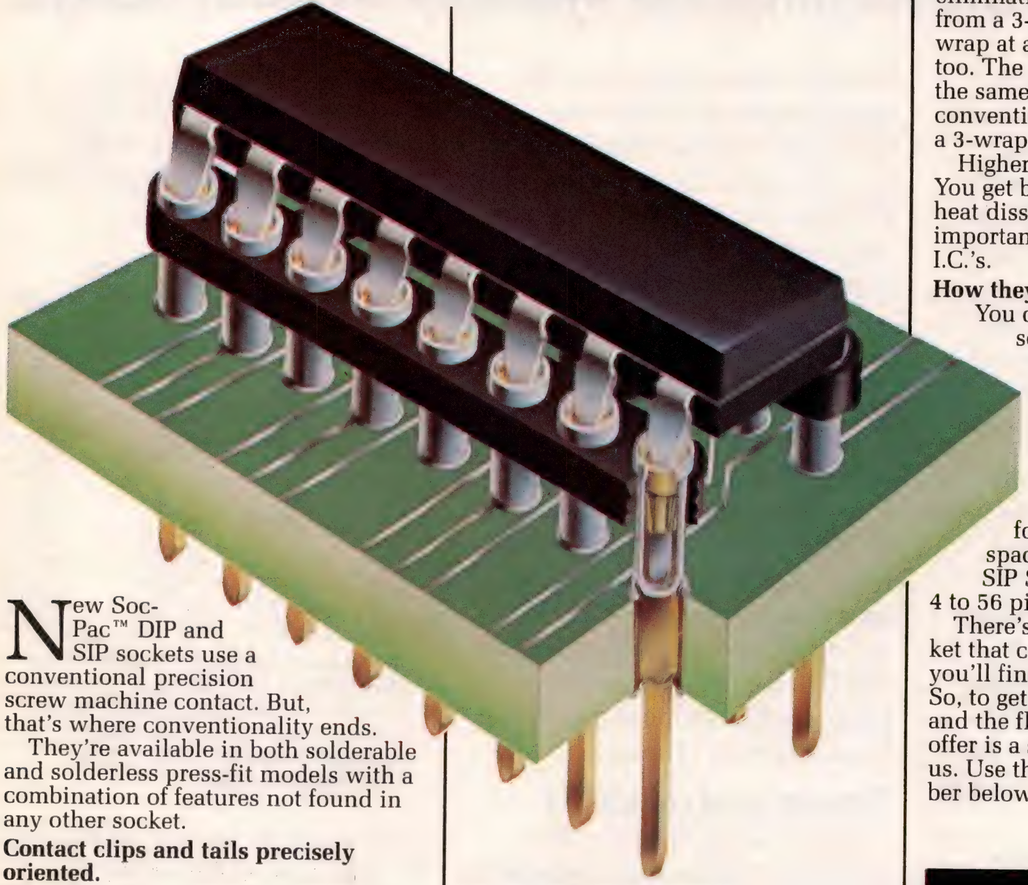
CIRCLE 41

A major improvement over traditional I.C. packaging methods.

How a simple socket can mean greater reliability, greater design flexibility at a lower cost.



New Soc-Pac™ DIP and SIP sockets use a conventional precision screw machine contact. But, that's where conventionality ends.

They're available in both solderable and solderless press-fit models with a combination of features not found in any other socket.

Contact clips and tails precisely oriented.
Tines of each contact clip are precisely oriented for perfect alignment with I.C. leads. The result — four contact points at every lead every time, a redundancy that costs you no more than conventional designs.

Also, each tail is oriented square and parallel with the others to easily accept mating connectors.

Selective gold plating.
The contact clip is plated with 30μ in. gold over nickel. The screw machine contact can be selectively plated starting from the tip of the tail (.250″ minimum) — with the exact gold thickness you need. That can mean significant savings.

Solderless press-fit advantages.
With solderless press-fit Soc-Pac sockets, you get the savings that eliminating the soldering step make possible. And, you get a gas-tight mechanical *and* electrical interface with the plated-thru hole in the PCB. There are still more advantages to the Soc-Pac design.

Get higher density, more flexibility.
Contrary to the trend to low profile sockets, Soc-Pac sockets stand relatively high on the PCB. There are very good reasons for that.

It allows us to reduce pad size to 0.055″ on press-fit and 0.050″ on solderable sockets. Which means you can run a trace between contacts for greater printed circuit density. And greater design flexibility. Additional printed circuitry translates to eliminating at least one tail wrap — from a 3-wrap tail to a 2-wrap, or no wrap at all. You keep compactness, too. The two-wrap tail allows about the same board to board spacing as conventional low profile sockets with a 3-wrap tail.

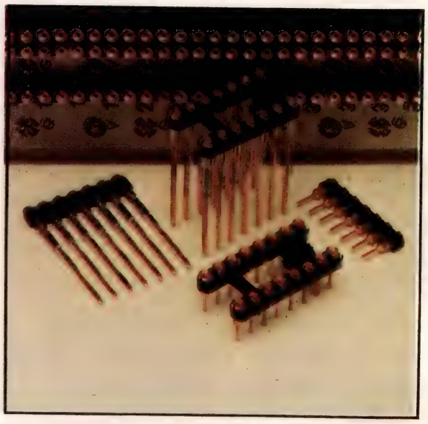
Higher sockets also add reliability. You get better air flow, thus better heat dissipation. That's particularly important with higher pin count I.C.'s.

How they come.
You can select either solderable or solderless press-fit Soc-Pac sockets in selective gold over nickel, tin, or nickel finishes.

DIP sockets come in 8, 14 and 16 pin counts for a 0.100″ x 0.300″ grid spacing and 24 and 40 pin counts for 0.100″ x 0.600″ grid spacing.

SIP Sockets come in strips from 4 to 56 pin counts.

There's no other socket on the market that combines all the features you'll find in the Soc-Pac™ socket. So, to get the savings, the reliability, and the flexibility Soc-Pac™ sockets offer is a simple matter of contacting us. Use the address and phone number below.



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CIRCLE 42

The automated placement and wire-routing of ECL for printed-circuit boards can upgrade existing computer designs with an economical investment of software and time.

Software eases a hard task—wire-routing ECL

When a reliable high-speed computer must be customized, even in very low quantities, only emitter-coupled logic (ECL) satisfies the objectives of speed and reliability; both TTL and Schottky circuits have drawbacks. Yet the attractions of ECL fade if the designer depends on manual methods for placement and wire-routing of ECL on printed-circuit boards. Manual design is slow and error-prone —and, therefore, costly. Here again, the designer has only one practical choice: complete automation.

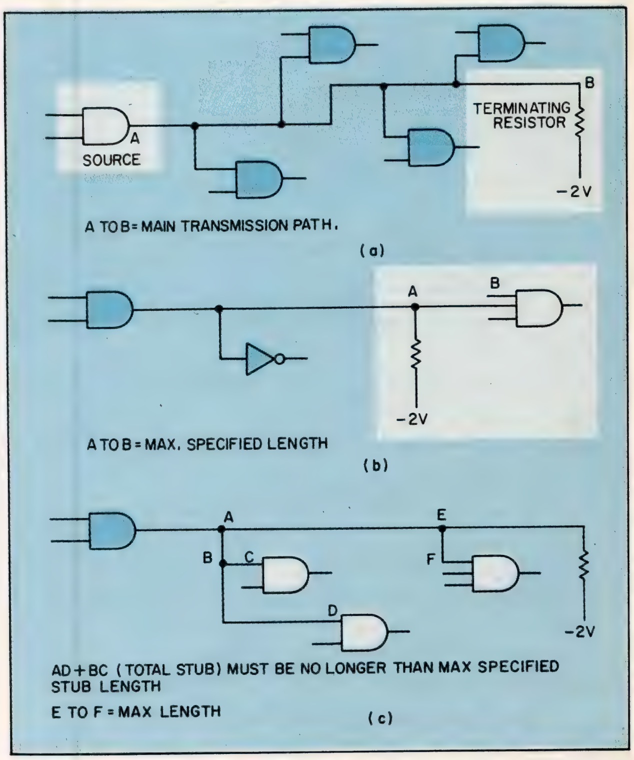
ECL, the only logical choice

When a computer must be fast, TTL is not suitable; though Schottky circuits are much faster, they present other severe restrictions, such as difficult-to-control reflections and excess crosstalk stemming from narrow threshold margins. TTL, however, could still be used where speed is not critical; and Schottky, where crosstalk and reflections can be controlled.

ECL is clearly preferable. It operates in a non-saturated mode; consequently, storage time is not a speed limiting factor. Equally important, ECL offers differential-amplifier input pairs that provide high-impedance inputs, and emitter-follower connected configurations that provide low-impedance outputs. These I/O characteristics allow large fan-out capabilities. Spacially distributed gate inputs can be tapped off along an interconnecting "transmission" line without producing reflections (impossible with Schottky). With such a net terminated at the end of the line, reflections are easily limited to a safe 55% of the noise margin.

After accounting for all ECL limitations, a practical fan-out of 10 to 15 gate inputs remains—far more than that are possible with Schottky. Thus, ECL circuits require fewer chips to perform the same functions. (Of the several families of ECL logic available, the ECL-10000 series is the most widely sourced).

Schottky circuit boards hold one advantage: They can be designed by less efficient manual methods, because the circuits impose fewer restrictions. With ECL, transmission-line techniques must be employed. Therefore, a manual approach would require an immense investment of time and patience to


A
SOURCE
B
TERMINATING RESISTOR
−2V
A TO B = MAIN TRANSMISSION PATH.
(a)
A
B
−2V
A TO B = MAX. SPECIFIED LENGTH
(b)
A
E
B
C
F
D
−2V
AD+BC (TOTAL STUB) MUST BE NO LONGER THAN MAX SPECIFIED STUB LENGTH
E TO F = MAX LENGTH
(c)

1. ECL gates can be tapped-off the main transmission line over its total length (a) from source to terminating resistor (b) without causing excess reflections, if rules on fan-out and maximum length are followed. In addition, gates can be attached to the main line by short stubs, so long as the stubs are shorter than the specified maximum length (c).

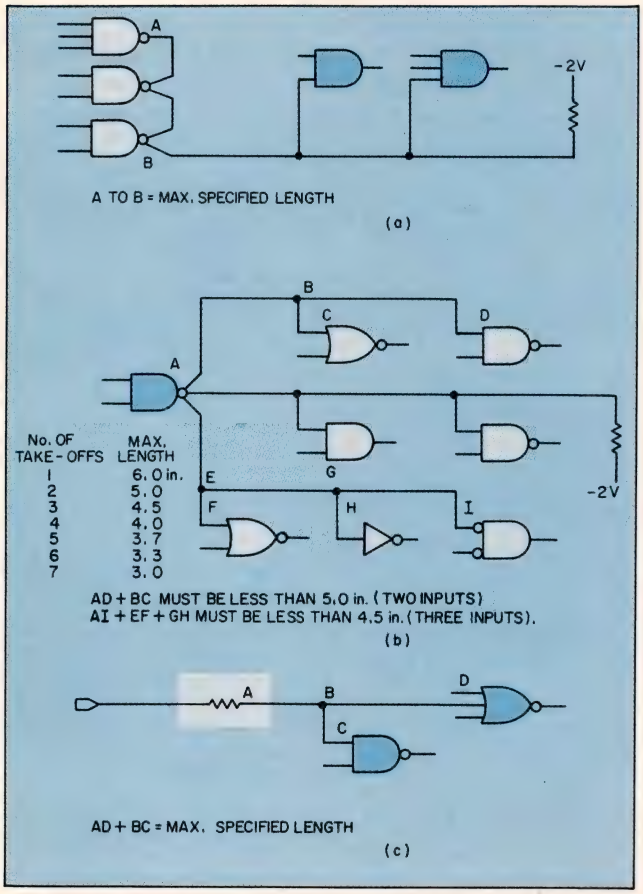
John A. Pierce, Director of Technical Services
Ed Malitz, Principal Member of Technical Staff
Formation, Inc.
Mount Laurel, NJ 08061
Mike Wilson, Manager of Application Engineering
Automated Systems, Inc. (Eastern Div.)
Blue Bell, PA 19422

overcome the almost unlimited opportunities for human error. Merely documenting such factors as parallelism and the lengths of signal nets—vital considerations in determining whether an ECL board will operate properly—would be a horrendous task for a manual designer. (Although, given all the time in the world, a manual designer could complete the job.)

When time is vital, so is automation

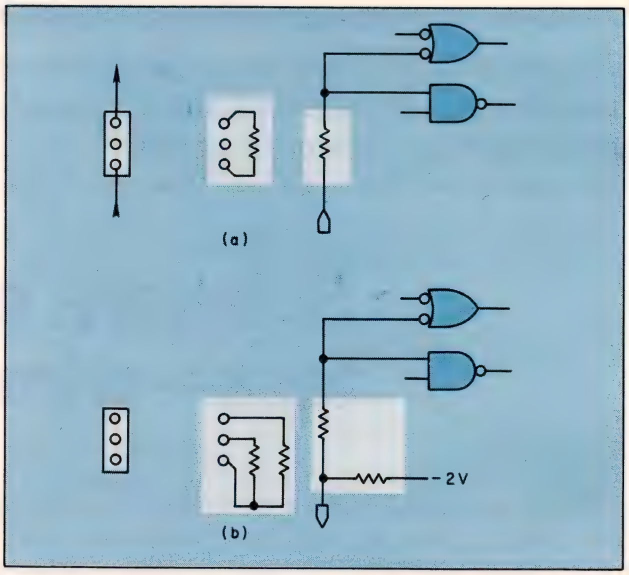
Automated design is the only practical approach. As a first step, all available information about the ECL circuit characteristics is compiled. The physical layout and construction of the circuit-board are determined, and preliminary wiring rules are organized. A "first pass" of these rules over the board design can then establish, with some lab work, whether calculations accurately match theory and practice. Part of this process is to calculate the maximum number of chips that can be handled on a single board, and to evaluate different styles of boards.

The specifications for wire-routing rules set two main requirements: enforcing gate-input stub-length controls and terminating the transmission lines properly (Figs. 1a through 1c).


A
B
-2V
A TO B = MAX. SPECIFIED LENGTH
(a)
B
C
D
A
E
G
F
H
I
-2V
AD + BC MUST BE LESS THAN 5.0 in. (TWO INPUTS)
AI + EF + GH MUST BE LESS THAN 4.5 in. (THREE INPUTS).
(b)
A
B
D
C
AD + BC = MAX. SPECIFIED LENGTH
(c)

No. OF TAKE-OFFS	MAX. LENGTH
1	6.0 in.
2	5.0
3	4.5
4	4.0
5	3.7
6	3.3
7	3.0

2. Sources can be connected in series (a), and they can supply "radial" nets (b); but length rules must be closely observed. When the signal source is from a location off the board, a series isolating resistor is included from the board-connector pin to the gate-net line (c).



3. Resistors for isolating (a) or terminating and isolating (b) are packaged in SIPs and DIPs at strategic locations on the circuit boards.

Merely specifying that stubs be as short as possible is inadequate; even worse is to ignore their length entirely. The precise location of terminating resistors is important also. These two requirements can sometimes be overlooked when circuit cards are small and signal lines short; but a system with large cards and relatively long lines operates correctly only with strict attention to the restraints.

The advantage of automated design is that a test board can be routed with, say, 1-in. max stub lengths as a first-cut design. Then, by changing only one instruction—the maximum stub length—values of 0.5 or 0.25 in. can be tried quickly and the resulting routing densities compared for practicality.

Existing program modified for ECL

Indeed, the program for ECL does not have to be written from scratch. Automated System's wiring-layout program for TTL, called PRANCE (Placement, Routing and Numeric-Control Editing), has been modified to provide a basis for and facilitate the work involved in designing ECL boards. Incorporating the ECL routing rules and the transmission-line technology into PRANCE necessitated many modifications to existing PRANCE software modules, plus the development of new modules. The PRANCE ECL/TTL system is available on a service bureau or lease basis to any firm involved in designing ECL boards.

Because the program incorporates all wiring information, it also can partition circuits for minimum interboard connections, indicate where boards should plug into the back panel for shorter cross-connections and maximum effectiveness, and also provide full documentation.

For example, a PRANCE-designed computer (see "PRANCE Answers a Call for Speed"), with more than 40 connectors on two racks and about 5000 interconnections on the backplane, needed extensive documentation. Just listing the signal name for each pin on every card, its source and where the associated terminating resistor is located would be an overwhelming task, if done manually. PRANCE makes the task easy by processing all the ECL boards and most of the TTL boards in the system.

The ECL transmission-line modifications and the rules for assignment and placement included in PRANCE minimize discontinuities along the transmission line, terminate transmission lines in the right places and separate signal paths to minimize reflections and crosstalk.

The signal source (or sources) is always placed at the extreme end of a fan-out string, or net; and the signal flow is along a continuous serial line with take-offs as required to the last input (Fig. 1a). At the input that is furthest from the source pin, or within a maximum specified distance, a terminating resistor is connected to match the line's impedance and thus help eliminate reflections (Fig. 1b).

The gate inputs, when necessary, can be attached by short wire lengths, or stubs, that are tapped-off at serial points along the main transmission line. The stubs lengths are kept within a customer-specified maximum (typically 0.25 in.; may be zero). A stub can connect to another stub so long as the total length is within the maximum specified (Fig. 1c).

In a multisource net, the sources connect serially and then to the main transmission path. The maximum distance between any two sources is automatically kept less than a specified distance, typically 5 in. (Fig. 2a).

A source also can drive a terminated main transmission line—the longest path from the source—plus several unterminated paths, called radial nets (Fig. 2b). An unterminated path is not allowed to exceed a specified length, which depends on the number of take-off points it supplies (see table, Fig. 2b). The lengths include all stub lengths, when stubs are used.

Nets with no sources on the card are treated differently. The signal is first routed from a card-connector pin to an isolating resistor, thus placing the resistor in series with the paths to any gate inputs (Fig. 2c). Such gates are located so as to make sourceless nets shorter in overall length than sourced nets. Maximum lengths for sourceless nets can be specified separately in the program. Resistors for this function (also for terminating) are packaged in SIPs or DIPs at specified board locations (Fig. 3).

Finally, signal paths that run parallel also have overall length limitations. Lines are generally considered parallel when they run along parallel-grid lines, spaced 0.075-in. or closer, for cumulative lengths in the range of 20 to 25-in., typically. The program flags those lengths that are in violation of customer specifications. Later software (post processor) cleanup can reduce the parallelism.□

PRANCE answers a call for speed

The vintage RCA-3301 system of a large regional telephone company represented a major investment in 3301 software—but a losing cause in speed and throughput. The company desired a new system, with at least five times the throughput of the old, that could be built with off-the shelf components to keep costs within reasonable bounds and that would run on the existing hardware.

The PRANCE wiring layout program for TTL processed all 55 ECL boards and about 60 of the TTL boards in the new system. The ECL-10000 circuit boards for the system were given the following characteristics:

- Four-layered construction that entails two outer layers for signal routing; a power-plane layer, split for −5.2 and −2-V power; and a ground-plane layer
- Conducting layers that are all 2-oz. weight
- Dielectric layers of 0.018 in. that separate signal layers from adjacent conductor plane layers
- Circuit "wiring" that is typically 0.012-in. wide, spaced no closer than 0.05 in., having an impedance of 75 Ω.

If the measure of a program for automated design, wire-routing and documentation lies in its results, then the PRANCE program scored a success. The resulting computer system, called Formation 9903, compares favorably with the most advanced contemporary systems and its data rate is three times that of the 3301. It runs on the existing application software, but at a work throughput up to 10 times that of the original system.

With its flexible architecture and a sophisticated new operating system, the computer features modular expandability and can accommodate the latest high-performance disk and tape-drive subsystems. A comprehensive switching system allows its peripheral devices and memory to be shared by up to four processors.

Where high-speed logic systems are required, the PRANCE ECL/TTL design software can fill the need economically.

How useful?	**Circle**
Immediate design application	**553**
Within the next year	**554**
Not applicable	**555**

Why our award-winning, Non-Noble Thick Film Networks will take you through the 80's.

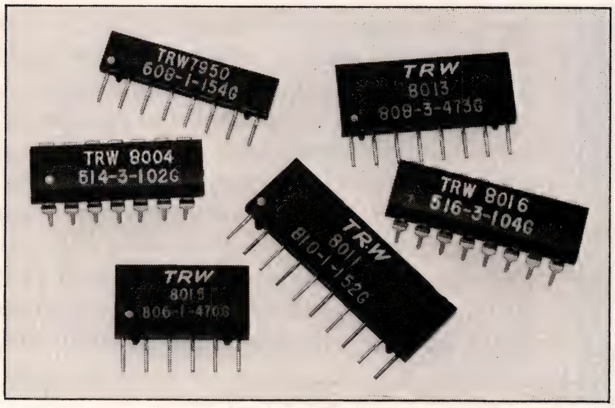
Now you can have the industry's first networks not tied to the increasing cost of precious metals such as ruthenium, palladium, silver and gold.

TRW has the material and the products for the changing 80's. Just in time to handle your needs.

The materials are screened base metal resistor and copper cermets fired in inert N_2 at up to 1000° C, chosen by *Industrial Research/Development Magazine* as one of the top 100 industrial product developments of 1978.

The products are thick film DIP networks, and SIP and low-profile SIP networks. Winner of *Electronics Products Magazine* new product of the year award in 1979.

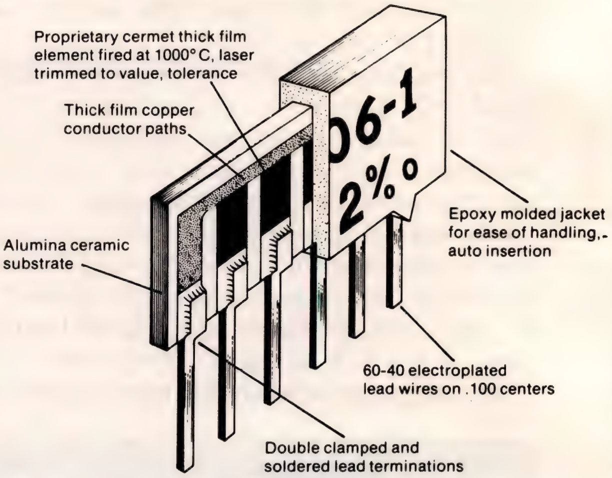
For more information on non-noble networks or our discrete non-noble Metal Glaze™ resistors, contact your local TRW/ECG sales office or TRW/IRC Resistors, an Electronic Components Division of TRW Inc., Greenway Road, Boone, N.C. 28607. Dept. N, (704) 264-8861.



TRW IRC RESISTORS

A DIVISION OF TRW INC.

Semi-Precision Metal Glaze™ Thick Film SIP Networks.


Proprietary cermet thick film element fired at 1000° C, laser trimmed to value, tolerance
Thick film copper conductor paths
Alumina ceramic substrate
06-1
2%
Epoxy molded jacket for ease of handling, auto insertion
60-40 electroplated lead wires on .100 centers
Double clamped and soldered lead terminations

- ☐ Feature TRW/IRC's non-noble thick film technology
- ☐ 6-, 8- or 10-pin packages
- ☐ Transfer molded for mechanical stability and automatic insertion

STANDARD RESISTANCE VALUES (OHMS)

33	180	1.0K	5.6K	33K	180K
39	220	1.2K	6.8K	39K	220K
47	270	1.5K	8.2K	47K	270K
56	330	1.8K	10K	56K	330K
68	390	2.2K	12K	68K	390K
82	470	2.7K	15K	82K	470K
100	560	3.3K	18K	100K	560K
120	680	3.9K	22K	120K	680K
150	820	4.7K	27K	150K	820K
					1 MEG

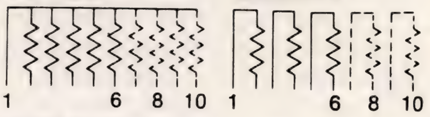
ELECTRICAL SPECIFICATIONS

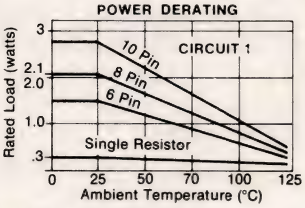
Resistance Range: 33 ohms to 1 Meg
Resistance Tolerance: ±2%, ±5%
Temperature Coefficient: ±200 ppm/°C
TC Tracking: 50 ppm/°C typical
Power Rating at 25°C: (see derating curve)

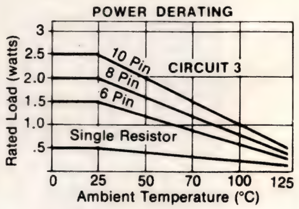
Circuit 1	6 Pin	8 Pin	10 Pin
Total package	1.5W	2.1W	2.7W
Single resistor	.3W	.3W	.3W
Circuit 3			
Total package	1.5W	2.0W	2.5W
Single resistor	.5W	.5W	.5W

(Rating at 70°C is 67% of 25°C rating)
Maximum Continuous Working Voltage: 50V
Operating Temperature: −55° to +125°C

STANDARD CIRCUITS (Resistors all same value)

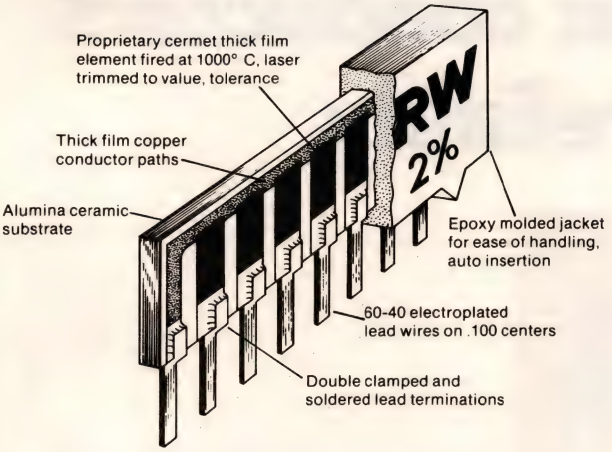






PART NUMBERS: 6 Pin: 806-1, 806-3; 8 Pin: 808-1, 808-3; 10 Pin: 810-1, 810-3.

Low-Profile Metal Glaze™ Thick Film SIP Networks.


Proprietary cermet thick film element fired at 1000° C, laser trimmed to value, tolerance
Thick film copper conductor paths
Alumina ceramic substrate
RW
2%
Epoxy molded jacket for ease of handling, auto insertion
60-40 electroplated lead wires on .100 centers
Double clamped and soldered lead terminations

☐ Feature TRW/IRC's non-noble thick film technology

☐ 8-pin package

☐ Project only .195 in. from PC board

☐ Height consistent with DIPs

STANDARD RESISTANCE VALUES (OHMS)

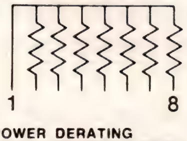
33	150	680	3.3K	15K	68K
39	180	820	3.9K	18K	82K
47	220	1.0K	4.7K	22K	100K
56	270	1.2K	5.6K	27K	120K
68	330	1.5K	6.8K	33K	150K
82	390	1.8K	8.2K	39K	—
100	470	2.2K	10K	47K	—
120	560	2.7K	12K	56K	—

ELECTRICAL SPECIFICATIONS

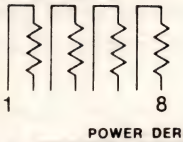
Resistance Range: 33 ohms to 150K
Resistance Tolerance: ±2%, ±5%
Temperature Coefficient: ±200 ppm/°C
TC Tracking: 50 ppm/°C typical
Power Rating at 25°C: (see derating curve)
  Circuit 1, total package - 8 Pin, 1.25W;
    single resistor - 8 Pin, .18W
  Circuit 3 total package - 8 Pin, .84W;
    single resistor - 8 Pin, .21W
  (Rating at 70°C is 67% of 25° rating)
Maximum Continuous Working Voltage: 50V
Operating Temperature: −55° to +125°C

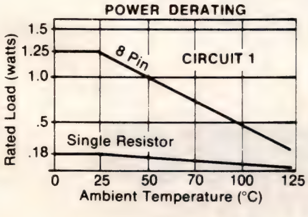
STANDARD CIRCUITS

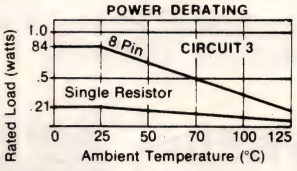
CIRCUIT 1



CIRCUIT 3

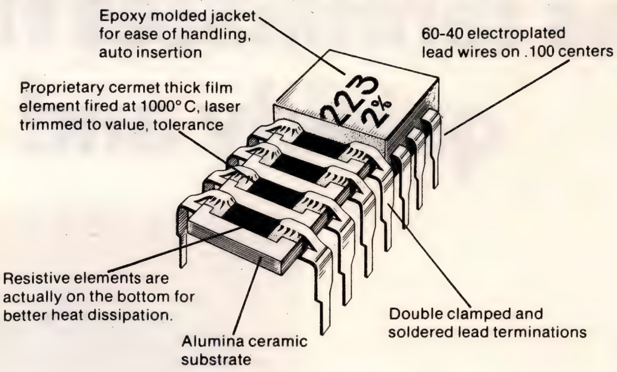






PART NUMBERS: 8 Pin: 608-1, 608-3.

Semi-Precision Metal Glaze™ Thick Film DIP Networks.


Epoxy molded jacket for ease of handling, auto insertion
60-40 electroplated lead wires on .100 centers
Proprietary cermet thick film element fired at 1000° C, laser trimmed to value, tolerance
223
2%
Resistive elements are actually on the bottom for better heat dissipation.
Alumina ceramic substrate
Double clamped and soldered lead terminations

☐ Featuring TRW/IRC's non-noble thick film technology

☐ Project only .200 in. from PC board

☐ Transfer molded for automatic insertion

STANDARD RESISTANCE VALUES (OHMS)

33*	100*	330*	1.0K*	3.3K*	10K*	33K*	100K*	330K*
39	120	390	1.2K	3.9K	12K	39K	120K	390K
47*	150*	470*	1.5K*	4.7K*	15K*	47K*	150K*	470K*
56	180	560	1.8K	5.6K	18K	56K	180K	560K
68*	220*	680*	2.2K*	6.8K*	22K*	68K*	220K*	680K*
82	270	820	2.7K	8.2K	27K	82K	270K	820K

* Preferred Value 1 MEG *

ELECTRICAL SPECIFICATIONS

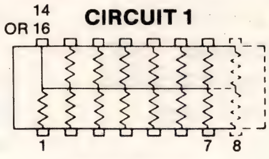
Resistance Range: 33Ω to 1 Meg
Resistance Tolerance: ±2% and ±5%
Temperature Coefficient: ±200 ppm/°C
TC Tracking: 50 ppm/°C typical
Power Rating 25°C: (see derating curve)

	14 Pin	16 Pin
Circuit 1		
Total package	1.625W	1.875W
Single resistor	.125W	.125W
Circuit 3		
Total package	1.75W	2.00W
Single resistor	.25W	.25W

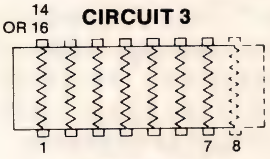
(Rating @ 70°C is 80% of 25° rating)
Maximum Continuous Working Voltage: 100V
Operating Temperature: -55°C to +125°C

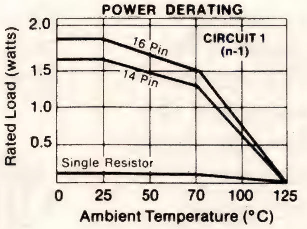
STANDARD CIRCUITS (Resistors all same value)

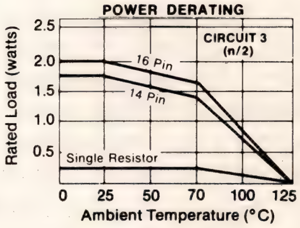
CIRCUIT 1



CIRCUIT 3



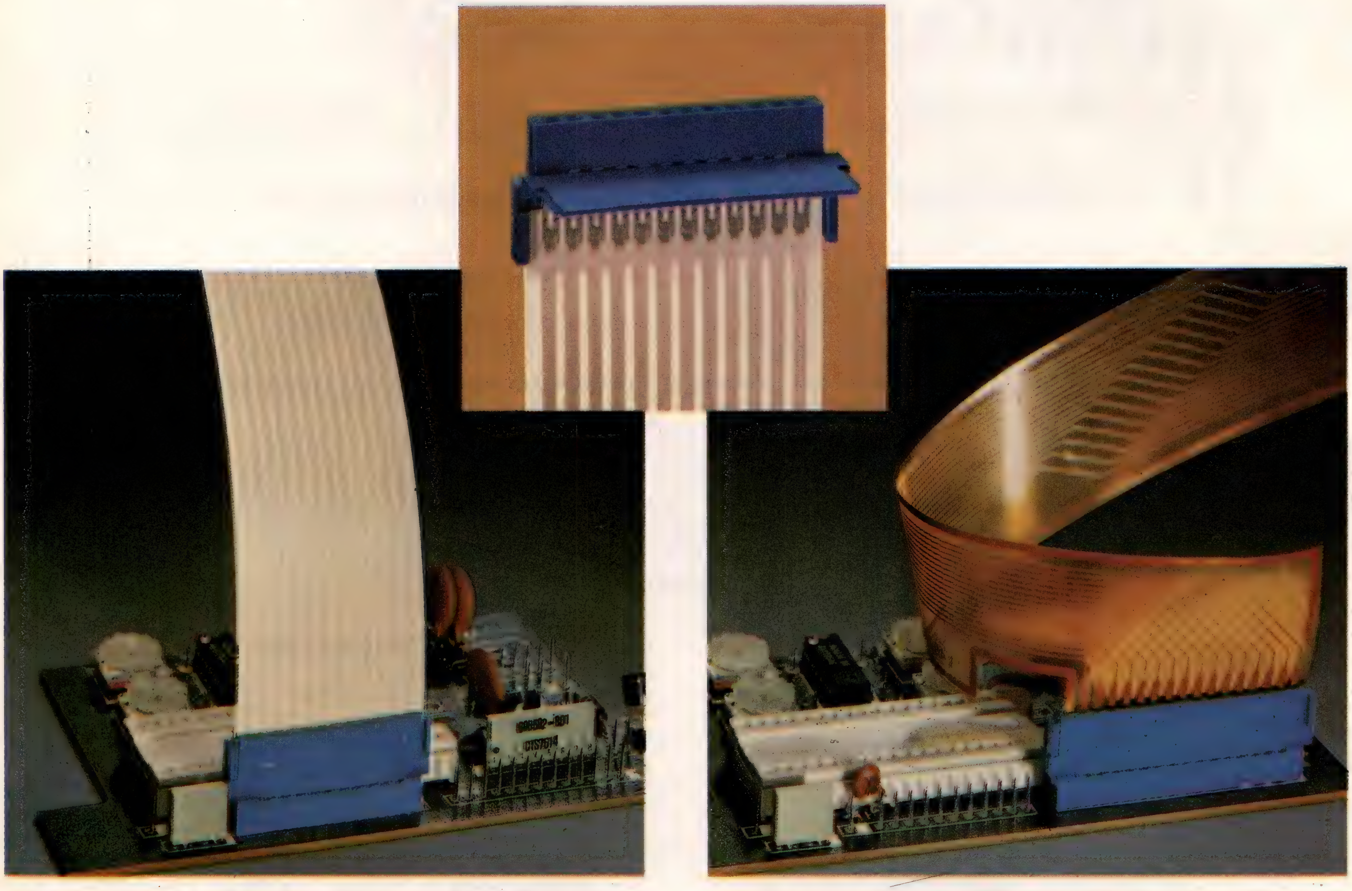




PART NUMBERS: 14 Pin: 514-1, 514-3; 16 Pin: 516-1, 516-3.

CIRCLE 43

Berg's Clincher* connector mass terminates flat conductors quickly and reliably.



The "Clincher" on flat conductor, flat cable.

The "Clincher" on flat conductor, flex circuitry.

The "Clincher" is a superior connector system for flat conductor, flat cable or flex circuits. It offers high reliability and the lower applied cost of mass termination.

With the "Clincher," all of the flat conductors are terminated simultaneously, within 15 seconds. Cable stripping is not required. The "Clincher" system offers a substantial reduction in total installed cost over individually terminated conductors.

The "Clincher" design uses Berg's proprietary PV* receptacle, a connector of proven reliability for over a decade in data processing and telecommunications applications. The dual-metal construction of the "PV" provides a high normal force to assure highly reliable mechanical and electrical performance.

Berg's "Clincher" accepts a 1 to 2 oz. copper 0.062'' wide cable. It is stackable on 0.100'' centers in double-row configurations for dense packaging. The "Clincher" mates with 0.025'' pins or standard Berg headers to form a complete interconnection system.

Rely on Berg for quality performance to meet your most demanding application needs. For a brochure describing the "Clincher" system, write or call:

The Du Pont Company, Berg Electronics Divison,
New Cumberland, Pennsylvania 17070.
Telephone: (717) 938-6711.

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*Du Pont Trademark

CIRCLE 44

Designing electronic equipment that runs cool yet quiet requires more than choosing low-noise air movers. Aerodynamic design factors count.

Design equipment to run silent, run cool

Although forced-air cooling of electronic packages has become virtually universal, a problem remains—unwanted sound in the operating equipment. The fans and blowers pushing air around inside the cabinets are major contributors, but choosing low-noise devices only partially solves the problem. Noise also depends on how effectively air is used for cooling—the better it moves, the less chance there is of aerodynamic energy dissipating itself in the form of sound (see box).

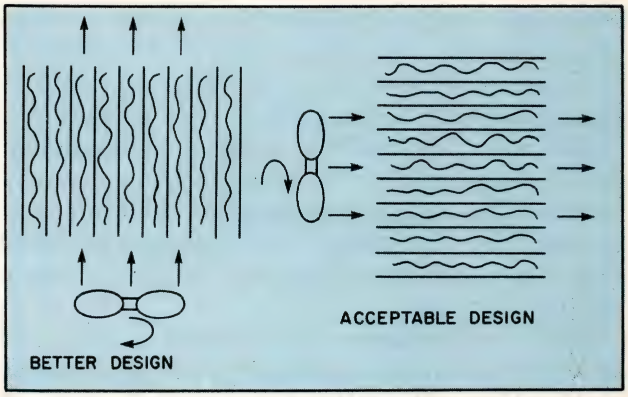
As a result, designers must also concern themselves with the efficiency and compactness of the cooling paths. At the board level, this means taking care not only with the PC-board design but also with the method of attaching the boards to racks—these factors contribute significantly to heat-transfer efficiency. At the system level, it means mounting the components to minimize the number of turns and obstructions in the air paths.

Take the heat off components

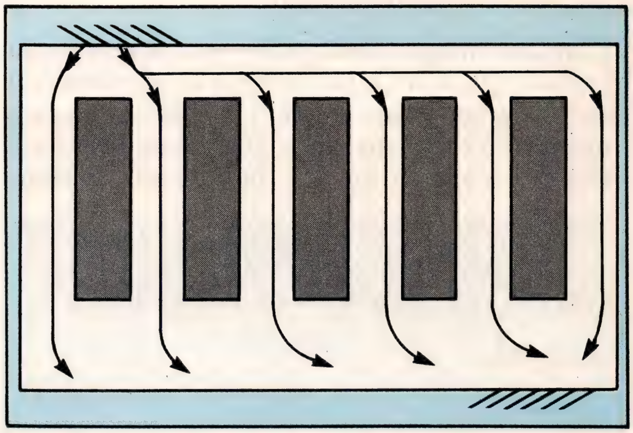
Effective conductive paths on PC boards can minimize heat-transfer requirements, allowing smaller air movers for overall system cooling. If possible, mount PC boards in vertical rather than horizontal racks so that natural convection can help remove heat generated by components (Fig. 1). Be aware of hot components, those requiring the highest heat-transfer rates. If a hot component is placed away from a direct air-flow path, air flow throughout the entire system must be increased. Thus, a larger air mover will be required.

At the system level, PC-board spacing in stacks should be large enough to minimize flow resistance—this will reduce the static pressure and allow the

Carlos C. Chardon, Chief Engineer
Information Systems Div.
Torin Corp.
Torrington, CT 06790



1. Mount PC boards in vertical racks when possible so that natural convection can contribute to heat dissipation.



2. Air-entry points low at the front of an electronic equipment cabinet and air-exit points high at the back minimize human exposure to fan noise.

air-flow rate to be maintained. Too large a spacing allows air velocity across the components to drop, jeopardizing heat-transfer efficiency. Tradeoffs must be made to optimize the board spacing.

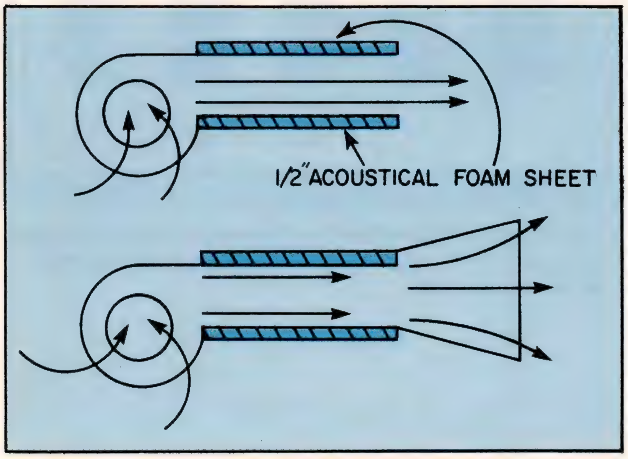
In addition, air entry and exit points should be isolated from operators because these spots are often sources of unacceptable noise. Typical air-entry locations are at the lower front or sides of the cabinet, with air-discharge points at the top sides or back (Fig. 2). Louvers and grilles should be selected for low pressure drops to allow a smooth air flow pattern through the system. Louvers over front-panel air inlets can serve as sound barriers.

To decrease the acoustical output, use sound-absorbing material such as sheets of plastic foam to cover the air-moving components (Fig. 3 top). The sheets can also be applied to the interior surfaces of cabinets and ducts. But be careful—this material is a heat insulator, and will cause an ambient temperature rise in the cabinet. With insulation, a larger fan will be needed to maintain the maximum specified temperature. Moreover, foam material can increase the air-flow resistance of the system. If interior space is available, an expansion chamber (Fig. 3 bottom) can be used as a muffler to reduce transmitted noise.

Once the equipment is configured to move air effectively, the next objective is to select an air mover that will run efficiently at the system's specified operating point.

Find the fan's operating point

The first design consideration is to determine the theoretical peak static efficiency of an air mover; the second, to determine whether the device actually operates at or near that peak. Theoretical peak static efficiency depends on two factors: the inherent



3. Sheets of acoustic, plastic foam attached to the inside of fan air ducts absorb some of the high-frequency noise at the outlet (top). But an expansion chamber (bottom), serving as a muffler, reduces this noise.

Sound of air—not music to equipment users

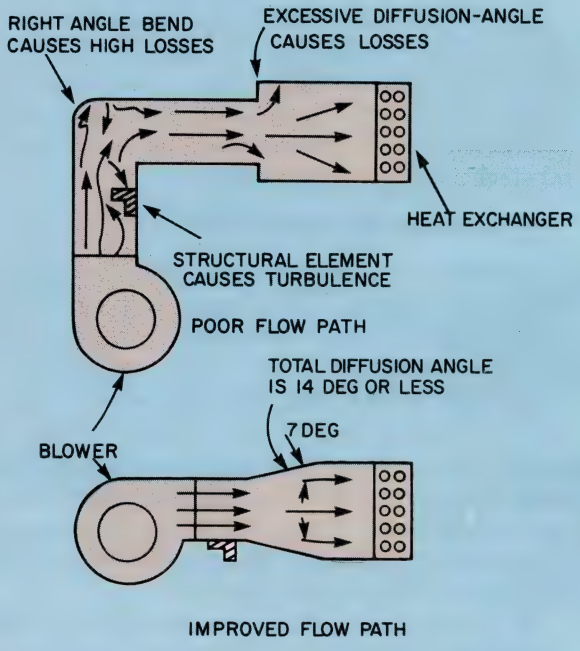
Noisy operation in electronic equipment stems from two different types of sound generated by air-moving components: aerodynamic and mechanical. Fortunately, air movers usually don't suffer from many sources of noise—one or two at most. But while some sources are relatively easy to eliminate, others are very difficult.

The main source of aerodynamic noise is air flow through the components of the air-moving device. This type of noise is characterized by discrete tones at several frequencies superimposed on a broad band of low-level sound (see the frequency scan of sound-pressure level).

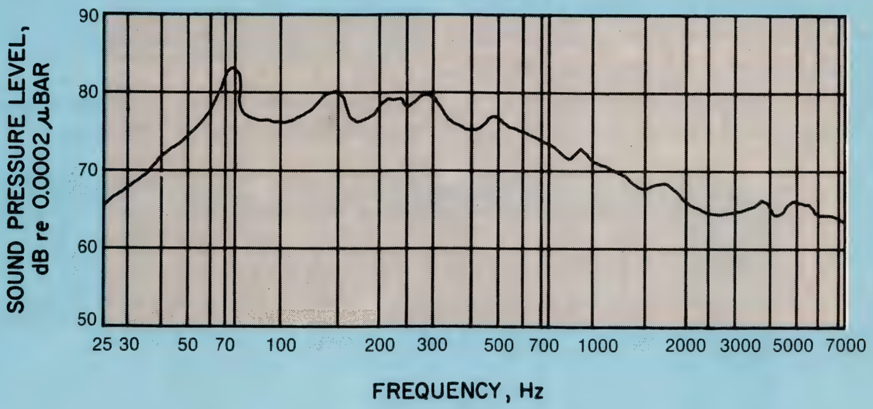
Another type of aerodynamic noise—discrete-frequency sound peaks—consists of periodic pulses created as the rotating fan blades pass near a stationary object. The fundamental frequency and harmonics of the pulses occur at multiples of the blade frequency. The frequency, f, of pure tones is found from

$$f = n\,(\mathrm{rpm}/60),$$

where n is either the number of points near the path of one blade or the number of blades passing one point.


RIGHT ANGLE BEND CAUSES HIGH LOSSES
EXCESSIVE DIFFUSION-ANGLE CAUSES LOSSES
HEAT EXCHANGER
STRUCTURAL ELEMENT CAUSES TURBULENCE
POOR FLOW PATH
TOTAL DIFFUSION ANGLE IS 14 DEG OR LESS
7 DEG
BLOWER
IMPROVED FLOW PATH

Broadband-fan noise is generated by vortex patterns and eddies emanating from the leading or trailing edges of the rotating blades. Vortex flow and eddies change with the air-flow rate and static pressure at the fan's operating point. There is a narrow range of operating points (combinations of air-flow rate and static pressure) where broadband noise is minimal, making fan operation more efficient. Good blade design minimizes the turbulence due to flow vortices, which decreases broadband noise while maximizing peak static efficiency over a narrow range.



Flow noise along the air path occurs where the air velocity is unusually high, or where there are obstructions in the path. When high-velocity air hits a thin sheet-metal wall, the result is called duct noise. Typically, this is low-frequency noise, in the range of 150 to 300 Hz. Duct noise occurs usually at elbows or abrupt turns in the flow path. However, turns and elbows can also be used to advantage—they decrease duct noise by increasing total system absorption.

A duct system having a diffuser distributes the air patterns for more uniform flow, but it must be the proper type of diffuser. A poor diffuser (Fig. A) is actually a source of additional noise. A good diffuser (Fig. B) maximizes aerodynamic efficiency.

On the mechanical side, problems are sometimes caused by natural obstructions that seem to belong in the flow system. Sharp-edged fan orifices can produce discrete frequency tones if small vortices of turbulence form at a sharp edge. Grilles, usually chosen for appearance, can be a source of pure tones. Even worse, grilles are often located at ear level, making noise more likely to be heard as it exits.

Two or more fans can generate acoustic beats produced by pure tones only slightly different in frequency. For example, two fans with blade frequencies of 125 and 135 Hz can produce a beat pulse that is the difference frequency between the two: 10 Hz. However, noise of this type is neither aerodynamic nor mechanical, and is not a major problem in cooling systems.

The most common source of mechanical noise is the ball or sleeve bearings on the rotating components. Sleeve bearings are generally less noisy, and little can be done to change the mechanical tone. Like acoustical beats, bearing noise is not as severe as aerodynamic noise.

Mechanical noise can also come from shaft resonance in the fan or blower, or from structural resonance in the cabinet or duct. When the rotational speed of a fan/motor assembly coincides with the natural frequency of shaft vibration, a resonant condition called critical-speed occurs. In itself, critical speed resonance is not a significant noise source, but it can induce other components to vibrate, thus resulting in serious noise problems. Cabinets and ducts sometimes produce noise without the phenomenon of critical speed resonance simply by vibrating at the driving frequency of the fan's rotation.

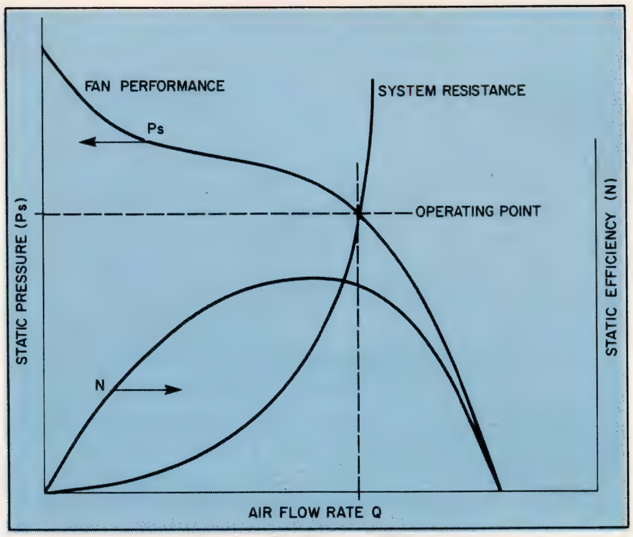
capacity of the fan and the specific characteristics of the particular model, including the shape of the impeller blades, housing or orifice.

Static efficiency (Fig. 4) is a function of specific speed (N_s), which is given by

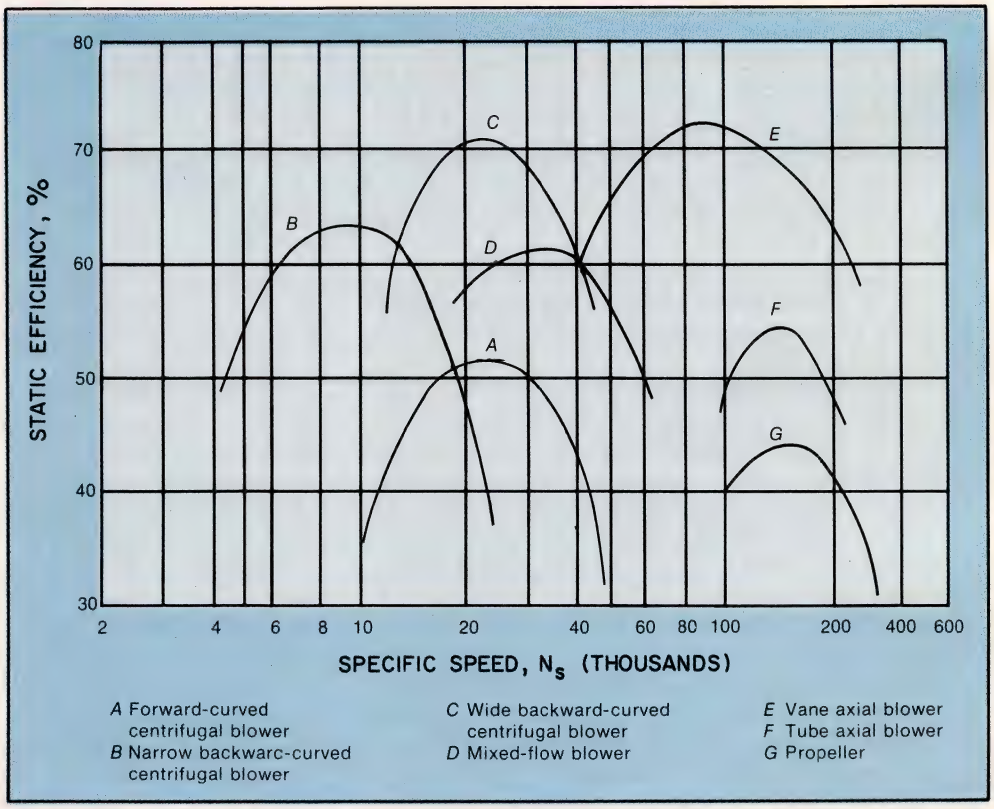
$$N_s = N\sqrt{Q}/P_s\ (3/4)$$

where N is the fan's rotational speed in rpm,
Q is the air-flow rate in cubic ft/min.,
P_s is the static pressure in inches of water.

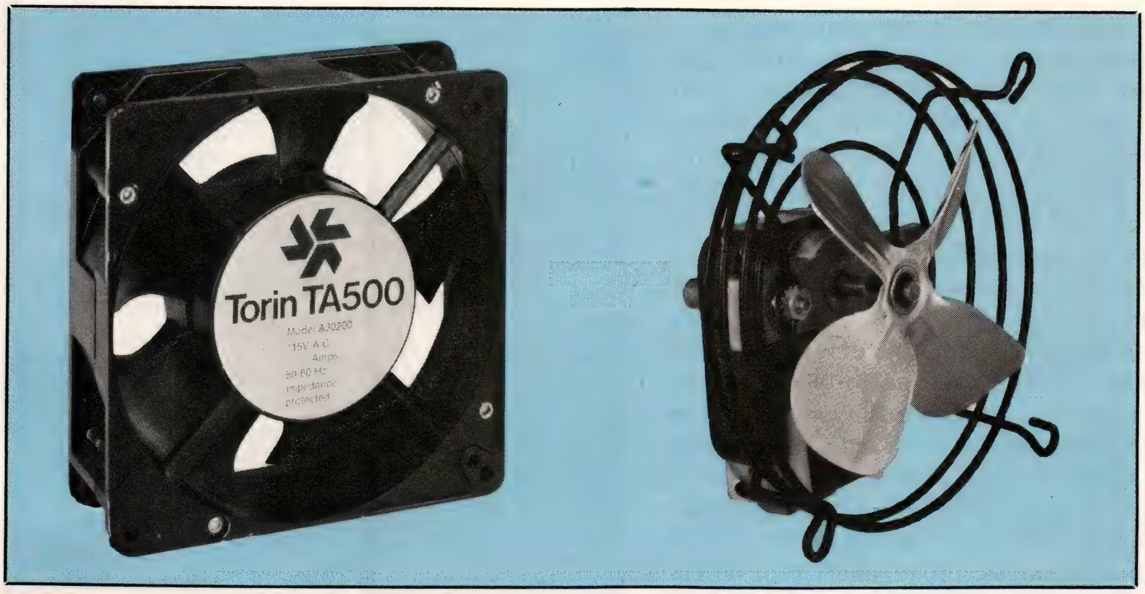
As shown in Fig. 5, a cooling fan's operating point is defined by a combination of static pressure, air-flow rate and fan speed where the system-resistance curve intersects a fan's performance curve. As a point on the system-resistance curve, the operating point represents the amount of static pressure needed to overcome the system resistance and maintain the required air-flow rate. As a point on the fan performance curve, the operating point represents the static pressure and air-flow rate that a particular



5. The operating point of an air mover should fall into the range of its highest static efficiencies.



4. Static efficiency vs specific speed is shown in this curve for the many types of air movers commonly used in electronic equipment.



6. A tube-axial fan (left) is constructed to fit standard electronic racks. Air-moving performance and cost are higher for tube-axial types than for propeller fans (right).

fan produces when rotating at speed N. Equilibrium is reached at the operating point—where the two curves intersect.

Fig. 4 also shows that a fan runs at or near peak static efficiency for a wide range of air-flow rates. To operate over this range, select an air mover by

1. Calculating the required N_s using values of air-flow rate and static pressure measured on a prototype in a heat-transfer test. Speed can be estimated according to the type of motor to be used with the air mover.
2. Determining, from Fig. 4, the type of air mover that will operate at or near peak static efficiency at the calculated value of N_s.

Since Fig. 4 contains the characteristics of many different fans and blowers, a designer should know the pros and cons of each type.

A fan for any application

Axial fans (curves E, F and G in Fig. 4) generally are most efficient at high specific speeds—relatively high air-flow rate and low static pressure. On the other hand, centrifugal blowers (curves A, B and C) operate most efficiently at low specific speeds.

For electronic-component cooling, tube-axial or propeller fans are the most widely used because of the low-pressure conditions found in electronic equipment (curves F and G). Tube-axial fans such as the modular 5-in. square unit in Fig. 6a are designed for rack mounting in electronic and computer systems. The integral motor is either a shaded-pole (3000 rpm typically) or a permanent split-capacitor (3450 rpm) type. While vane-axial units (curve E) have higher peak static efficiencies, they are more expensive and tend to be noisier because of their stationary flow-straightening vanes. A propeller fan such as the one in Fig. 6b is less expensive than a tube-axial, but it is also less efficient.

In the high-pressure cooling systems of mini and microcomputers, the tightly packed components produce higher heat loads and higher system resistance than in other electronics packages. The lower specific speeds of centrifugal blowers make them more efficient than fans in these applications. Moreover, backward-curved wheel units have higher peak static efficiency than forward-curved blowers (Fig. 4). While backward-curved designs find their way into critical low-noise applications, sometimes forward-curved units produce a quieter system. This is because the higher-pressure capability of the latter allows for lower operating speed and lower noise.

To help designers select a fan, manufacturers provide static-pressure-vs-air-flow curves such as those of Fig. 7. With a given air flow of, say, 80 cu ft/min., note that the graph offers three different Torin fans: a standard unit (TA500), a low-noise fan (TA500S) and a high-performance unit (TA500-PSC). Air flow in the PSC type is about 17% greater than the standard unit, while the low-noise fan provides superior noise characteristics by operating at a reduced speed.

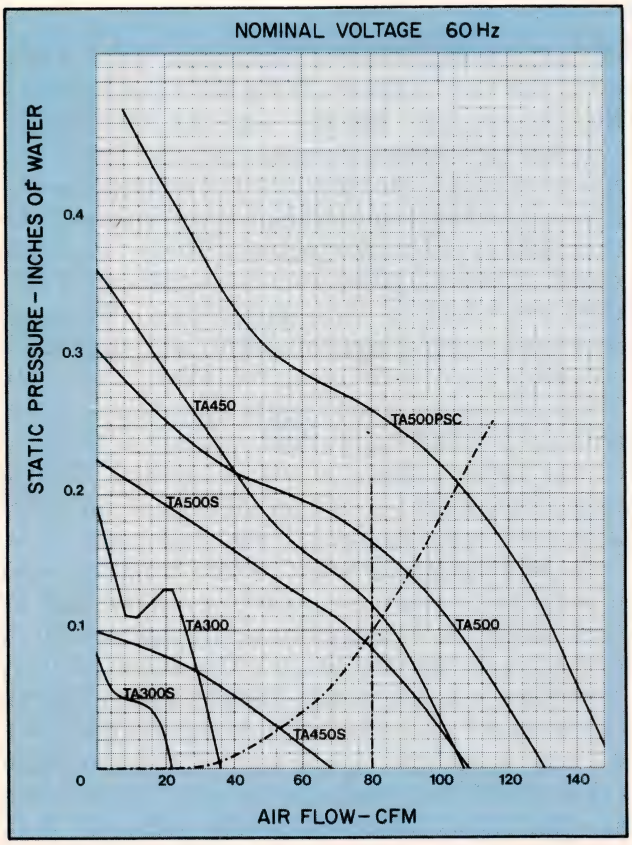
Sound ratings—what they mean

Speaking of noise characteristics, evaluating the sound performance of new equipment or debugging noisy prototypes involves not only accurate measurement of sound quality, magnitude and distribution—but "meaningful" ratings as well. In other words, fan and electronic-equipment manufacturers must use the same ratings and measure the sound performance of air movers in the same way.

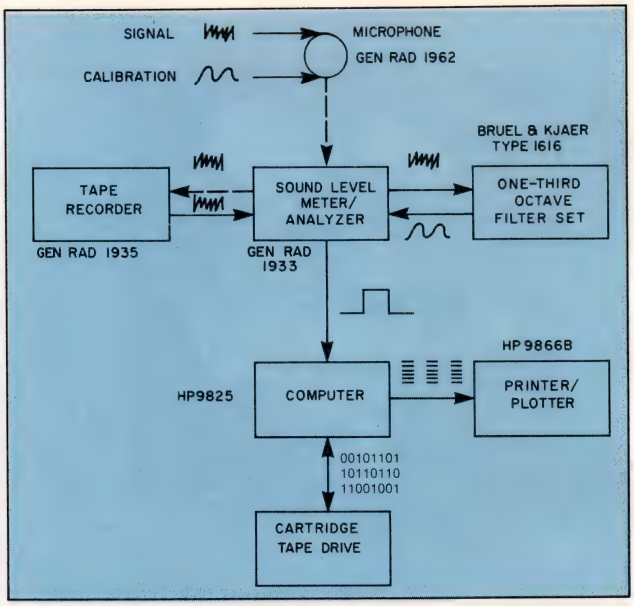
All sound is measured in two fundamental ways: sound-pressure level (SPL) and sound-power level (PWL). SPL, specified in dB referred to 20 micropascals, is measured directly with a sound-level meter. PWL, given in dB referred to 1 pW, can be calculated from SPL when testing is performed in a well-defined environment.

Sound-performance ratings based on PWL are preferred because they represent more accurately the behavior of a sound source regardless of measurement conditions. SPL varies at different points surrounding the source, so the spatial location of the measurement point must be specified. PWL, on the other hand, stands for the total acoustic power of a source, regardless of the point of measurement.

Both SPL and PWL can be measured within various frequency ranges: broadband (from 50 Hz to 10 kHz), limited-band (full octave or one-third octave) or narrow-band (a few cycles). In addition, broadband SPL and PWL measurements can be weighted by passing the signal through the widely used bandpass networks: A-scale, B-scale and C-scale. A-weighting most closely approximates the human-ear response by deemphasizing low-frequency sound (up to 500 Hz) and concentrating instead on the frequency range, 500 Hz to 10 kHz.



7. Performance curves like these for a family of tube-axial fans help the designer choose a model that delivers at least the required air-flow rate and static pressure.

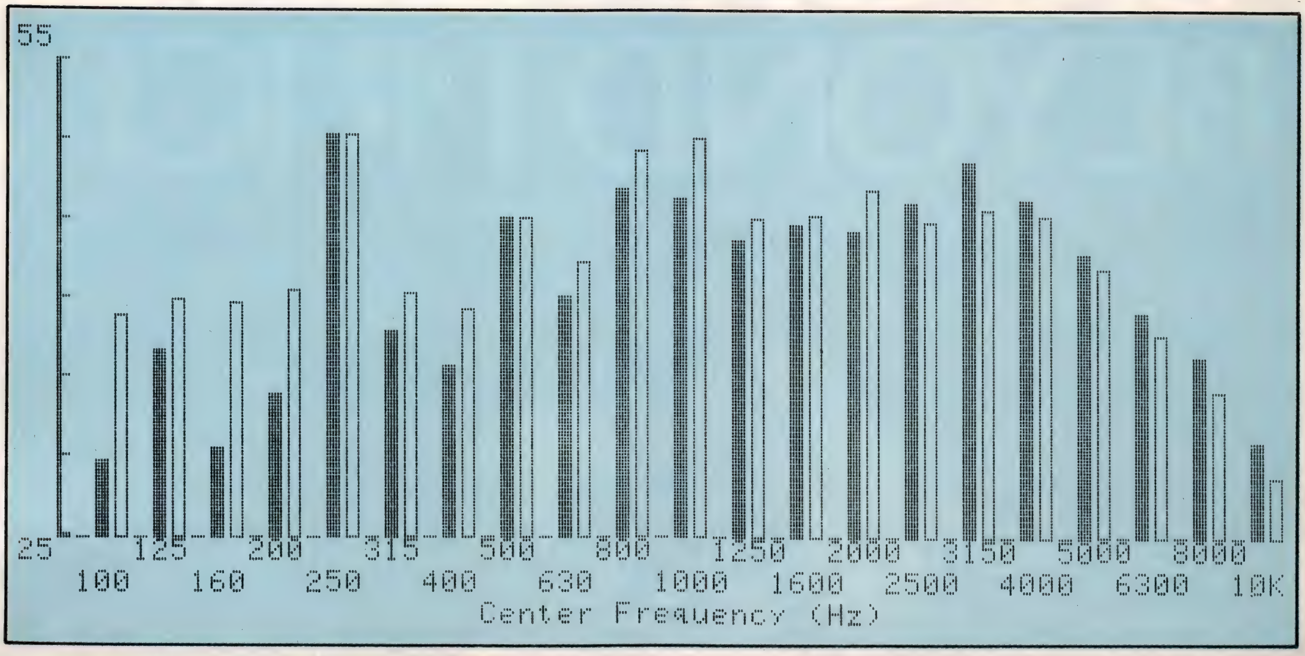


8. The complexity and variety of sound measurement make an automated sound-analysis system an important aid for both measurement and computation.

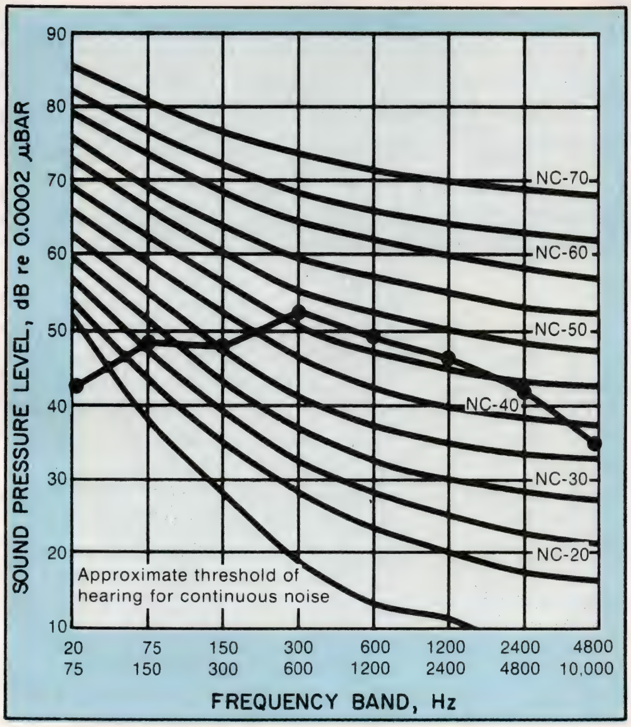
Sound characteristics can be measured in a semi-anechoic chamber that contains both reflective and sound-absorbent walls, thus combining the characteristics of reverberant and anechoic rooms. In such a chamber, PWL is calculated from six SPL measurements made on an imaginary sphere centered on the sound source. The formula for computing PWL must take into account the particular features of the sound chamber.

To analyze sound, to collect meaningful data and to calculate in various sound-rating units, use an automated sound-analysis system (Fig. 8), which improves the accuracy of computing and generating final reports. Once the sound is recorded on magnetic tape in analog and digital formats, the analysis system can present the data for evaluation in a number of ways. Fig. 9 is a multiple-bar chart showing a full set of one-third-octave PWLs.

Two other sound-rating systems—noise criteria (NC) and perferred noise criteria (PNC)—were originally devised to define acceptable background noise in various environmental surroundings. NC data, shown in the curve of Fig. 10, are a plot of maximum SPLs in eight octave bands. Curves NC-20 through NC-70 each represent a different type of environment: NC-30, for example, is an acceptable limit for



9. In this bar chart of sound power levels (PWLs) at one-third octave-band center frequencies, the dark bars show fan operation at zero static pressure, while the light bars show the system operating point.



10. Noise-criteria (NC) data are provided on a graph in which each curve is a plot of the maximum acceptable sound pressure level (SPL) in the eight octave bands.

motion-picture theaters, while NC-20 applies to concert halls. Note that the rising slope of all the curves at low frequency represents the human ear's reduced response to low-frequency sound.

PNC ratings are similar to NC ratings except that they reflect a customer's particular specifications. Basically, then, they are updated NC ratings with slight adjustments to level values.

Other measurement units coming into vogue, especially for the sound characteristics of cooling fans, are noise power-emission level (NPEL) and preferred sound interference level (PSIL). NPEL, given in units of bels, is defined as one-tenth of the A-weighted sound power level over the full sound spectrum.

PSIL, measured in dB, was developed to account for the degree to which noise interferes with speech —in work locations where speech is necessary. Since nearly all speech information falls in the 200 to 6000-Hz frequency range, the greater the SPLs in this range, the greater their speech-masking effect. PSIL is represented by a single figure—the average of three SPLs in octave bands centered on frequencies of 500, 1000 and 2000 Hz. As with NC ratings, it is possible to show maximum allowable PSIL numbers that provide acceptable noise levels in different types of operating environments.☐

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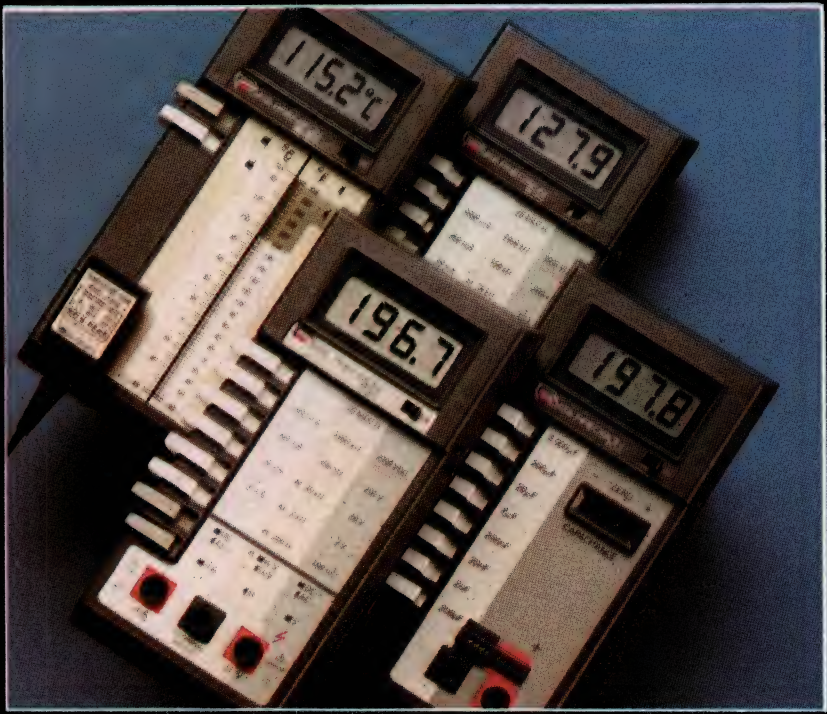

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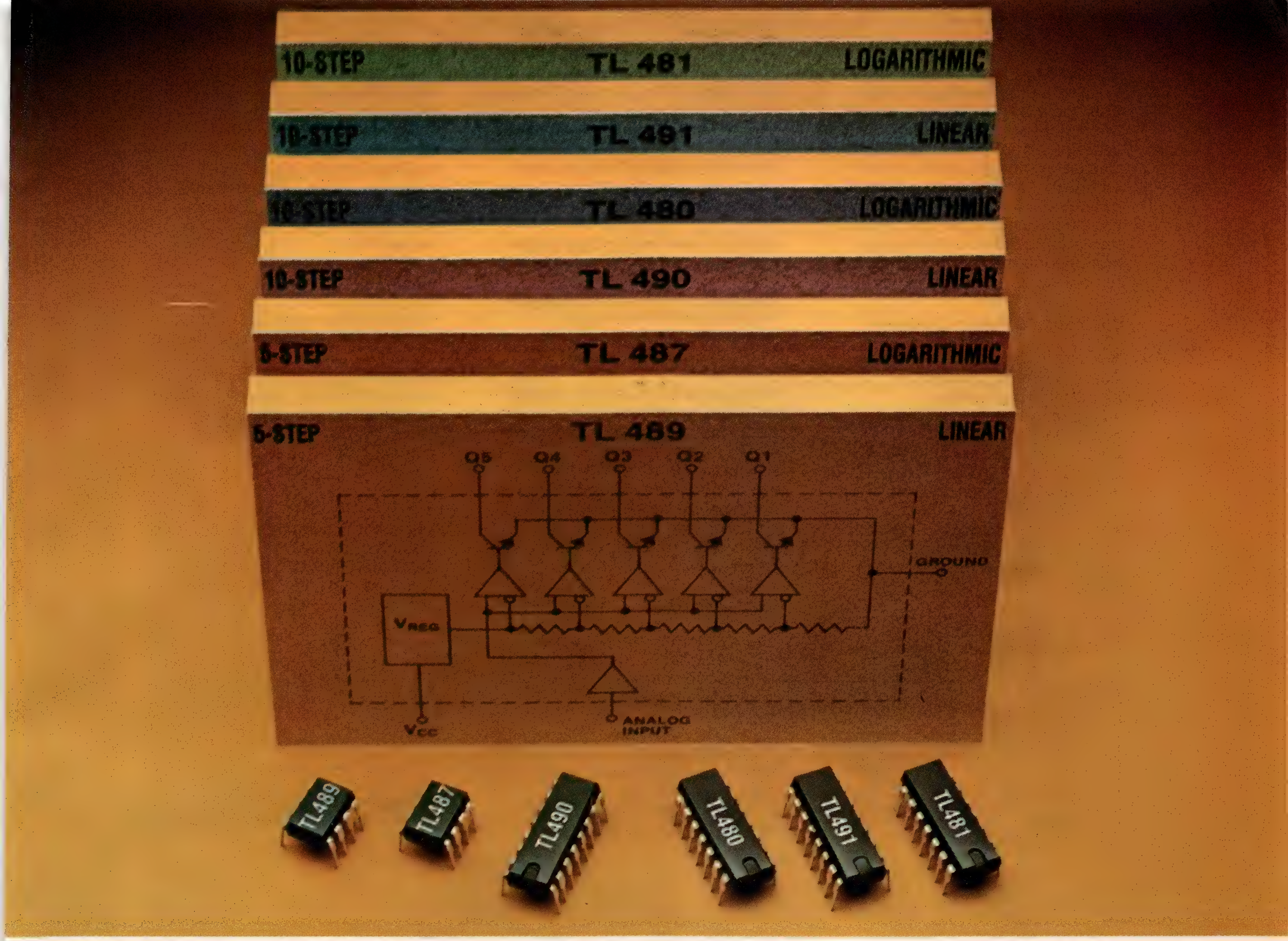

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A thin-film resistor network stretches ADC performance

A precision resistor string, a switch and an op amp develop a 10-bit analog-to-digital converter (ADC) from an 8-bit ADC (National Semiconductor's ADC 0801). The 10-bit resolution is possible because the resistor string (single thin-film network) takes advantage of the 8-bit ADC's differential input.

The thin-film network divides the analog input voltage range into four spans, each equal to $V_{REF}/4$. The LF356 op amp buffers the lower portion of the network to provide half the reduced span voltage to the $V_{REF}/2$ input (pin 9) of the ADC 0801. Thus, each of the four spans attains 8-bit resolution.

The switch selects the offset voltage for each span and applies it to the $V_{IN}(-)$ input. (The switching function could be microprocessor controlled using a μP output port and an analog multiplexer. The microprocessor would search for the 2 most-significant bits over the four spans and would add them to the 8 least-significant bits from the ADC output —to achieve 10-bit resolution.)

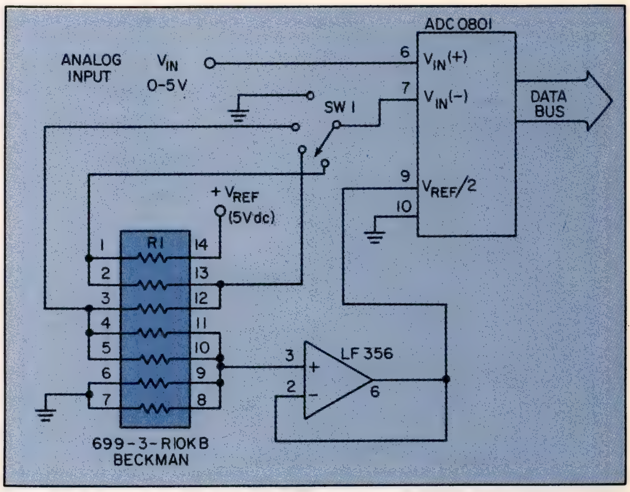
The reduction of the analog span creates a need for accurate and stable voltage inputs. For the four spans of 1.25 V each, a 1 LSB error is equivalent to 5 mV at the analog input and 2.5 mV at the $V_{REF}/2$ input.

Here is where the characteristics of the thin-film resistor network make the application work. The standard network contains many resistors with identical values, but resistance available can be varied by changing the way the elements are connected (parallel and/or serial). The precise tolerance, matching and temperature tracking of the thin-film network are retained, regardless of the user's external circuit configurations.

Under worst-case conditions the thin-film network will contribute 2/3 LSB of error (max). With typical performance, the network will contribute less than 1/2 LSB, and the error with temperature change (25 to 70 C) will be just 0.211 mV, or less than 1/10 LSB. The V_{REF} supply voltage accuracy will also contribute to the total error.

With a $2 thin-film network, an $8 ADC and a $2 op amp and switch, a 10-bit ADC with ±1 to ±1.5 LSB accuracy can be built for about $12.

Stephen T. Ford, Product Manager, Network Products Operations, Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, CA 92634. **CIRCLE 311**

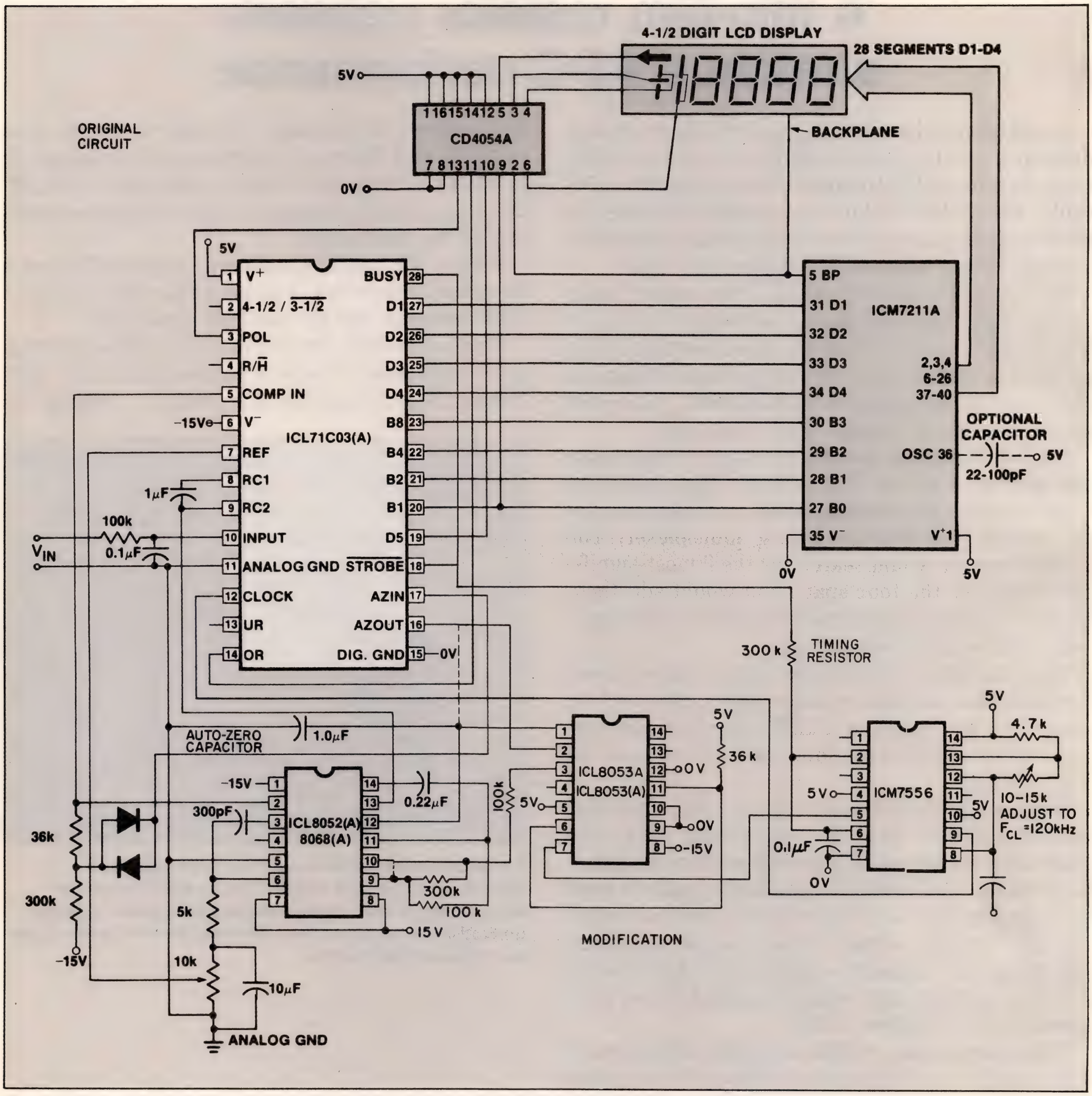


An inexpensive thin-film resistor network gets 10-bit performance from an 8-bit ADC. For simplicity, a manual switch (SW1) is included for selecting each of four network-derived offset voltages. This switching function easily adapts to microprocessor control.

Eliminate overrange 'hangover' in autozeroed ADCs

In DVMs, DMMs and data aquisition systems, the autozeroed dual-slope analog-to-digital converters (ADCs) for digital readouts can produce inaccurate readings (hangover) immediately after input signal overloads. But the problem is eliminated by adding two ICs and a few discrete components to the ADC circuit. The components zero the ADC's integrator output at the beginning of each autozero cycle.

Multiplexed systems are especially degraded by hangover. An overload on just one channel disturbs the reading accuracy of data samples taken on several succeeding channels. The residual voltage on



1. By zeroing the integrator output at the beginning of each auto-zero cycle, this circuit prevents input voltage overloads from affecting the analog-to-digital converter's short-term accuracy. Hangover (visible in the LCD) resulting from settling time is eliminated.

the ADC integrator is transferred, as a transient, to the autozero system. The autozero system must resettle before accuracy is restored. The process can take up to ten conversion cycles, the worst case occuring when the full-scale buffer and integrator swings are equal.

For example, the Intersil ICL8052/ICL71C03 precision 4¼-digit ADC (chip pair) is subject to hangover after exposure to certain input overloads. The problem is corrected by modifying the autozero connection with a ICL 8053 switch and half of a ICM7556 dual timer (Fig. 1).

Now the comparator output (ICL71C03 AZOUT) connects to an inverting input on the buffer during the first part of the original autozero cycle (phase 1) and to the 1.0 μF autozero capacitor during the remainder of the cycle (Fig. 2). Half of the ICM7556 timer controls the timing cycle; the other half forms the clock oscillator. The ICL8053 functions as a single-pole double-throw switch and was chosen over more conventional switching schemes because of its lower charge-injection into the autozero capacitor.

A good approximate setting for the zero integrator time is between one-third and one-half of the minimum autozero time. If an "optimum" adjustment is required, an oscilloscope can examine the integrator output under worst-case overload conditions. The output of the delay timer should stay low until after the integrator has returned to its starting point (Fig. 2).

Under nonoverload conditions, a small "zero integrator" phase is desirable, but the full cycle time is not required. A P-channel MOSFET placed across the 300-kΩ timing resistor reduces the time constant when overrange does not occur. Alternatively, a three-diode network can be used, or a two-input OR gate.

Also, the ICM7556 timer introduces a delay from the beginning of the conversion interval until the zero integrator phase is enabled. This delay should not exceed the input integrate time. (When the circuit is modified, this factor should be checked.)

Zeroing the integrator output at the beginning of each autozero cycle is also an advantage with the ICL8052/ICL7104 16-bit binary chip set. However, the timing must be derived from the STATUS output.

Peter Bradshaw, Analog Applications Manager, Intersil, Inc., 10670 N. Tantau, Cupertino, CA 95014.

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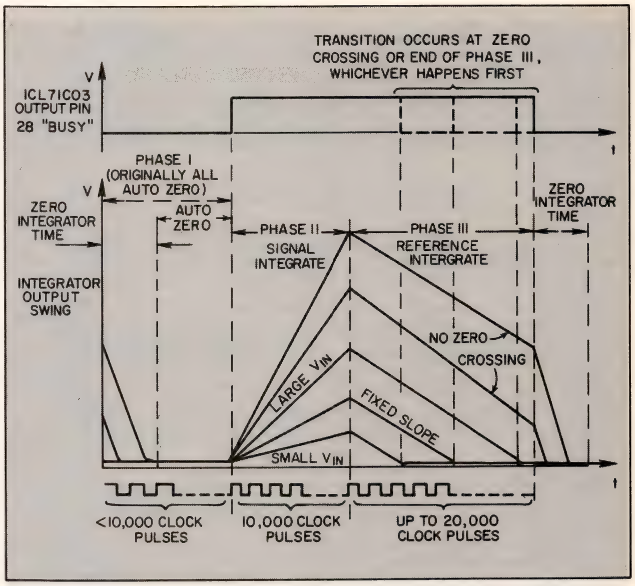


2. Circuit modifications to eliminate hangover effectively split phase I of the ADC's timing diagram into two sections. Now the AZOUT pin connects to an inverting input on the buffer (zero integrator time) before it connects to the auto-zero capacitor. Switching is handled by the ICL8053.

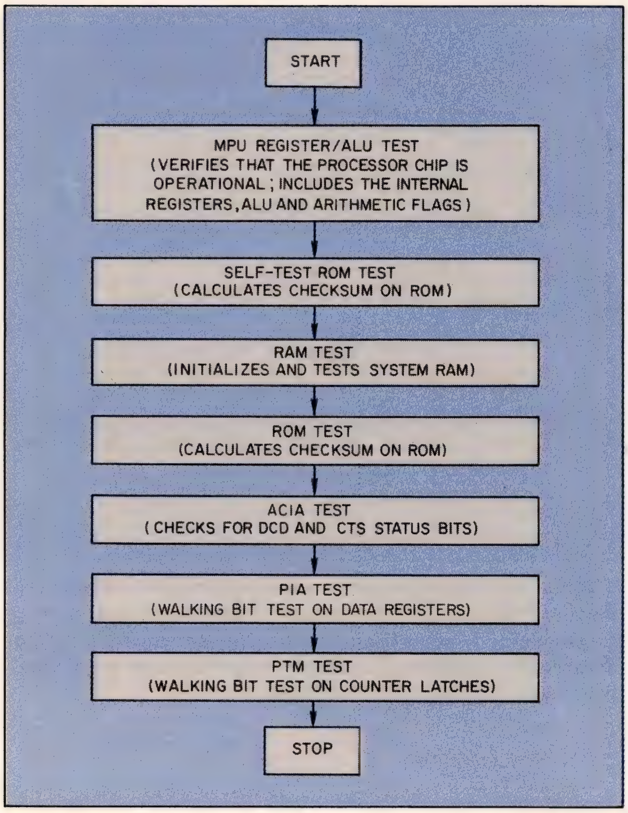
ROM-resident software self-tests microcomputers

A self-test program that resides in ROM within a 68000-based microcomputer supersedes logic analyzers, automated circuit testers, complex test procedures and experienced technicians, for production testing and diagnosis of hardware failures. This self-verification routine can also function as an in-house systems test. Status indicators on the front panel give the customer feedback should the system fail in the field.

A typical 68000 system contains a processor, system RAM, debug or boot ROM and the terminal and printer I/O. A programmable timer and the self-test

ROM must be added. The self-test ROM should be located logically as close to the MPU chip as possible, so a minimum amount of support circuitry connects the MPU to the ROM. This circuitry, known as the "kernel," should be isolated from the rest of the system by buffers whenever possible, to prevent faults that could interfere with the self-test. Logic is also necessary within the kernel to provide I/O between the MPU and a front panel.

Prior to the self-test, the entire kernel is assumed to be functional—the 68000 processor, the self-test ROM, the minimum support logic and the front panel logic. The self-test program first verifies that this assumption is correct and then branches out beyond the kernel to test the remainder of the system (see figure). The seven self-tests include MPU register/ALU verification, self-test ROM verification, system RAM test, system ROM test, terminal ACIA test, printer PIA test and PTM test.


START
MPU REGISTER/ALU TEST (VERIFIES THAT THE PROCESSOR CHIP IS OPERATIONAL; INCLUDES THE INTERNAL REGISTERS, ALU AND ARITHMETIC FLAGS)
SELF-TEST ROM TEST (CALCULATES CHECKSUM ON ROM)
RAM TEST (INITIALIZES AND TESTS SYSTEM RAM)
ROM TEST (CALCULATES CHECKSUM ON ROM)
ACIA TEST (CHECKS FOR DCD AND CTS STATUS BITS)
PIA TEST (WALKING BIT TEST ON DATA REGISTERS)
PTM TEST (WALKING BIT TEST ON COUNTER LATCHES)
STOP

The self-test program flow first verifies that the 68000 processor chip is operational. While running, the test program should not output any extraneous data to the terminal or printer (this would only confuse the operator).

The MPU register/ALU test verifies the operation of the 68000 processor and each of the internal registers. The test also checks out the ALU and the carry, negative, zero and overflow flags. All this is accomplished by arithmetic operations and transfers of data to and from the address and data registers.

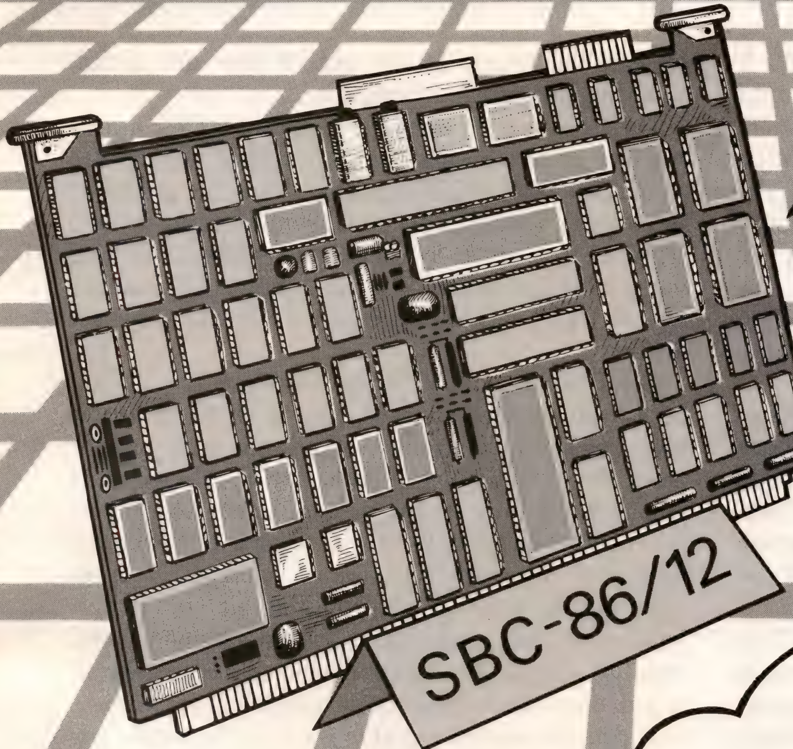
In testing the registers, each bit location must be checked to make sure it can store both low and high states and that it is unique with respect to every other bit in every other register. By setting a register to all ZEROs and marching in a field of ONEs or setting a register to all ONEs and marching in a field of ZEROs, the program tests each bit location within the register. Since adjacent memory cells are most likely to affect each other, complementary data are stored in registers that are adjacent on the die. For example, on the 68000 chip, all the odd-numbered registers must have the same data and all the even numbered registers must have complementary data.

A few arithmetic operations test the carry, negative, zero and overflow flags. Loading a register with \$00000001 resets all the flags. Adding \$FFFFFFFF to this register sets the carry and zero flags. Subtracting \$80000000 from the result sets all of the flags (with the exception of the zero flag). Thus, all flags have been set both high and low, and the processor has proved it can perform addition and subtraction.

The self-test ROM verification calculates a checksum on the ROM contents to show that the kernel is operational, that the MPU can read all locations in ROM and that the ROM contains valid data. Specifically, the 68000 executes a routine that performs a 16-bit addition on the entire contents of the ROM. It then checks the accumulated result against a known value.

The RAM test initializes and tests all of memory. It is executed out of ROM and easily tests 256 kbits of RAM within a few seconds. First, it performs a march test that initializes the entire memory and verifies that all of the addresses are unique. Second, it performs a walking-bit test on several locations in memory, ensuring that all of the data lines are independent of each other.

The march test first stores ZEROs in each location



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CIRCLE 49

in RAM. Then, starting at the bottom of RAM, it reads the location and writes the complement until the entire memory contains ONEs in every location. It then starts at the top of memory, reads the location and writes the complement, proceeding until the entire memory has been cleared to ZERO. If at any time, the data within a location do not compare to what the test wrote, the test exits immediately. The address of any faulty location(s) should be stored in an address register, along with the data written into RAM and the data read back.

If the march test is successful, then the walking-bit test is initiated. The walking-bit test walks a ZERO in a field of ONEs and a ONE in a feld of ZEROs through several locations in memory, always comparing data immediately after they are written. A miscompare generates fault information similar to that from the march test.

The walking-bit test is performed on the first location in memory and at 1-kbit intervals to ensure that all the data buffers and at least one location in each RAM has passed (performing a walking-bit test on every location in RAM would significantly lengthen the test, while the gain in fault diagnostics quality would be minimal).

Most address and data failures can be detected by the combined RAM tests, provided the memory is configured with 1-bit wide RAM components. Much more complicated testing is required for 4-bit or 8-bit wide RAMs.

The debug or boot ROM test is similar to the self-test ROM verification, in which a checksum is calculated on the entire ROM. If the system contains several ROMs, then a checksum must be calculated on each to detect faults and (if any are found) generate diagnostic information.

The ACIA test merely reads the ACIA status register. It also checks that no extraneous data are transmitted to the CRT terminal. Here, the processor first resets the ACIA by storing a $03 in the control register; it then reads the status register. It makes sure the ACIA senses the clock input (DCD status bit set high) and the terminal (CTS status bit set high).

The PIA and the PTM tests are similar, in that both perform a walking-bit test on their respective data registers. Since no extraneous data can be transmitted to the peripherals, the walking-bit test is performed only on the data registers and not on the control registers. In this way, none of the control signals or interrupt bits are set on the I/O chips.

In testing the PIA, the walking-bit test is performed on data direction registers and peripheral registers. If the PIA is connected to a line printer, extraneous data will not be outputted on the printer, provided the control register is set not to toggle any control lines leading to the printer. Inputs must be masked unless they can be changed by an associated output.

In testing the PTM, the walking-bit test is performed on all three counter latches. The control register setup must prevent the PTM from decrementing any of these counters.

Stephen Strom, Electrical Engineer, Motorola Inc., Microsystems Div., P.O. Box 20906, Phoenix, AZ 85036.

CIRCLE 313

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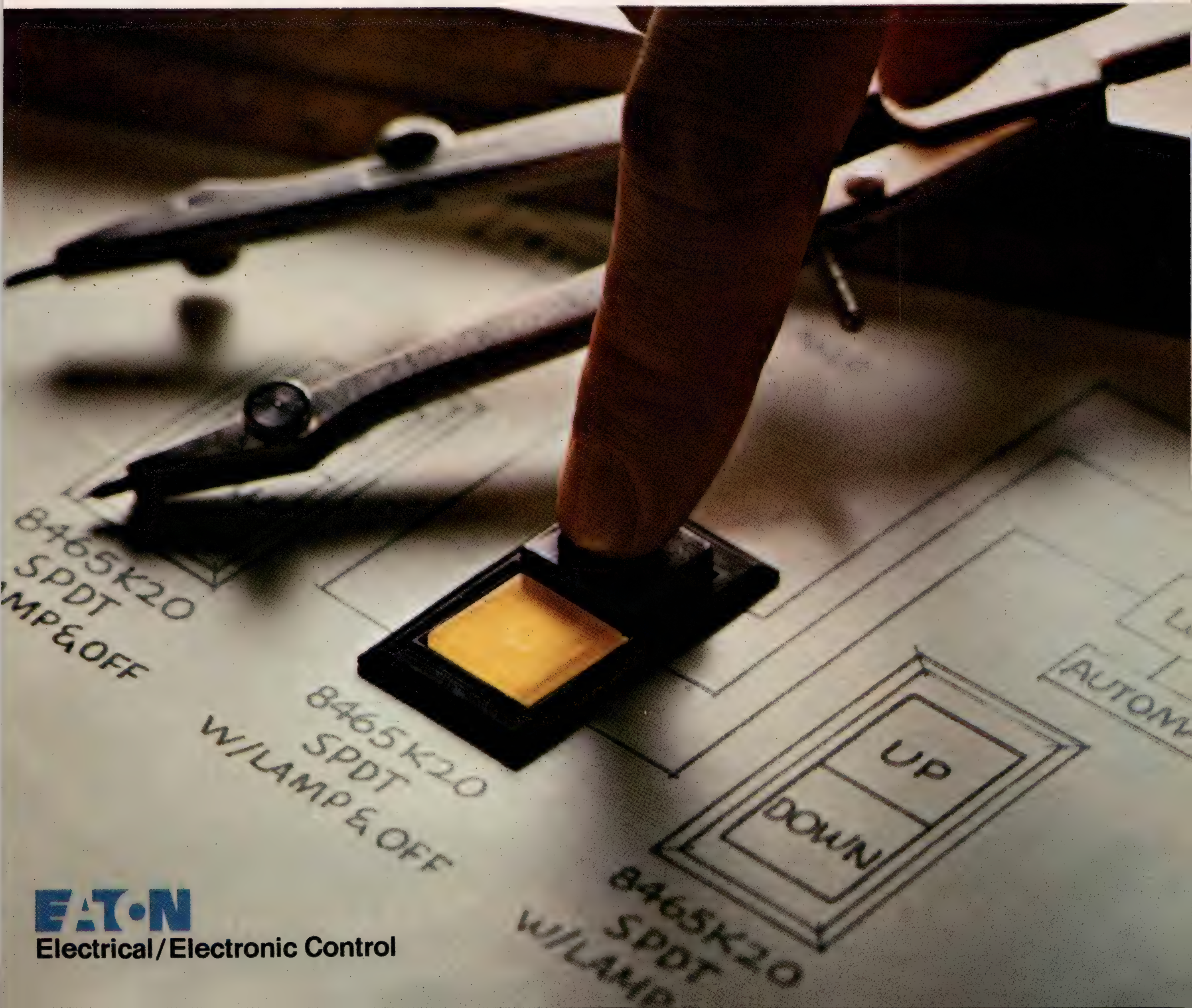

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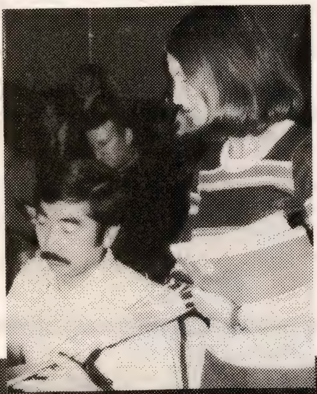

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MONDAY/LINEAR I

Three New Linear Families. New video SOS a/d flash converters, CA3179 1.3-GHz prescaler, divide-by-4 prescaler and precision BIMOS op amps are introduced. Hal Wittlinger, RCA, Somerville, N.J.

ICL7650 Glitchless Chopper-Stabilized Amplifier. Offers low offset voltage and exceptionally low input bias current at a very attractive price. Skip Osgood, Intersil, Cupertino, CA.

Am6300 Power-Supply-Control Subsystem. Computer-controlled, power-supply controller for sophisticated power-supply systems. Brian Gillings, Advanced Micro Devices, Sunnyvale, CA.

National's New Developments. A look at new low-power references, high-power regulators, and precision op amps coming from National Semiconductor.

DG211 4-Channel Switch. Fits a variety of low-cost applications. Jerry Mandel, Tom Cate. Siliconix, Santa Clara, CA.

CMOS Voltage Regulators, References and Voltage Detectors. Micropower devices covered include two-terminal voltage references, positive and negative programmable regulators and over-and-under voltage detectors. Jerry Zis, Intersil, Cupertino, CA.

New Voltage/Frequency Converter Techniques. New techniques lead to 18-bit a/d conversion with 1 ppm/°C gain stability. A 1.3-V (single-cell) supply circuit is also discussed. Bob Pease, National Semiconductor, Santa Clara, CA.

Analog/Digital LSI Design With I²L Gate Arrays. A cost-effective approach. Bill O'Neil, Exar, Sunnyvale, CA.

RM4200 Analog Multiplier. Applications for a precision monolithic multiplier/divider are covered. Jim Schmoock, Raytheon Semiconductor, Mountain View, CA.

TUESDAY/LINEAR II

The HI5900 and HI5712: A Complete Microprocessor-Compatible System. An analog signal-processing front end and a 12-bit a/d converter form a high-speed, high-performance data-acquisition system. Al Morton and Rich Antalik, Harris Semiconductor, Melbourne, FL.

New Texas Instruments' Op Amps and Interface Circuits. Discusses single-supply, n-channel, FET-input op amps, comparators, new EIA RS-422 line circuits and 3-A peripheral drivers. Dale Pippenger, Texas Instruments, Dallas, TX.

BUF-03: Industry's Fastest Voltage-Follower Amplifier. Boasts a 300-V/μs slew rate and 55-MHz bandwidth. Two applications are described. With an OP-16, it forms a current booster capable of driving heavy capacitive loads; with a 500-pF holding capacitor, it functions as a fast sample-and-hold amplifier. Shelby Givens, Precision Monolithics, Santa Clara, CA.

9708 8-Bit, 6-Channel A/D Converter and 9706 12-Bit 8-Channel D/A Converter. Use in microprocessor-based control systems described. John Conover, Fairchild Semiconductor, Mountain View, CA.

OP-220 Dual Micro-Power Op Amp. Industry's first low-power, high-precision dual op amp. Lowest input offset voltage, lowest bias current over temperature, and lowest input-offset-voltage temperature coefficient of any dual amplifier. CMVR includes ground which makes this device ideal for light, compact battery-operated instrumentation. Tom Schwartz, Precision Monolithics, Santa Clara, CA.

Microprocessor-Compatible Conversion ICs. Discussion of new a/d and d/a converters and sample-and-hold amplifiers. Steve Sockolov and Phil Marcoux. Signetics, Sunnyvale, CA.

New Motorola Industrial ICs. Describes IC drive system for stepper motors. Speakers to be announced. Motorola, Phoenix, AZ.

Monolithic ICs for FSK Modem Design. A two-chip FSK modem design. Joel Silverman, Exar, Sunnyvale, CA.

Power Interface Circuits. Introduces UDN-2949Z bipolar half-bridge motor driver and UCN-4202A stepper motor translator/driver. Paul Emerald, Sprague, Worcester, MA.

WEDNESDAY/MICROPROCESSORS I

Microcomputers From Intel in the 1980s. Integrating software into silicon; simplifying the interface to the user. Dane Elliot, Intel, Santa Clara, CA.

Introduction to Signal-Processor ICs. Features, architecture and instruction set described. Bob Holm, Intel, Santa Clara, CA.

The Intel 2920 Signal Processor. A discussion of 2920 applications. Bob Holm, Intel, Santa Clara, CA.

Microcontrollers: System-Designed

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Microcomputers. New signal processors and microprocessors. Dick Barck, American Microsystems, Cupertino, CA. Santa Clara, CA.

The S68045 CRT controller. Reduces CRT system cost design. Frank Toth, American Microsystems, Santa Clara, CA.

Motorola's New Family of CMOS Microprocessors. Five new CMOS ICs with a/d converter, RAM, ROM and EPROM on the chips. Jim Farrell, Motorola, Austin, TX.

Fast Error Detection and Correction for Memory Systems. Use of AM2960 16-bit EDC IC is described. John Mick, Advanced Micro Devices, Sunnyvale, CA.

MB1412A 8-bit-slice ECC IC. Use of error-checking-and-correction chip described. Alan Heimlich, Fujitsu Microelectronics, Sunnyvale, CA.

THURSDAY/MICROPROCESSOR II

The NS16000 Family: Support for Software Modularity. NS16000 architecture eliminates the need to modify machine code. Linking process illustrated. Brian Marley, National Semiconductor, Santa Clara, CA.

Software Solutions for Board Applications. The software exists to design your next microprocessor-based board product. Joanne Pearson, Intel, Santa Clara, CA.

Transparent Addressing Resolves Memory Contention in Terminal Application. SY6545 allows addressing of screen-refresh memory transparent to processor to improve overall design efficiency. Conrad Boisvert, Synertek, Santa Clara, CA.

Mask-Programmable Low-Power-Schottky Gate Array. Shrinking system design. Cliff Vaughan, Raytheon Semiconductor, Mountain View, CA.

2653 Polynomial Generator Checker. Performs block/check character and parity generation, checking, single-character detection and two-character sequence detection. Alex Goldberger, Signetics, Sunnyvale, CA.

Bipolar Arithmetic Devices Support New MOS Microprocessor. Multiplier/divider enhances performance of otherwise slow MOS microprocessor. Shlomo Waser, Monolithic Memories, Sunnyvale, CA.

NE5560 Switched-Mode Power-Supply Control Circuit. For flyback forward or double forward (push-pull) outputs, provides all control interfacing needed. Norm Matzen, Signetics, Sunnyvale, CA.

Leadless Carrier Memory Arrays. Describes applications techniques. Charles Hochstedler and Jeff Wilkinson, Harris Semiconductor, Melbourne, FL.

FRIDAY/MICROPROCESSOR III

Single-Chip Fairchild Microcomputers. Describes applications for currently available F3870 devices and explores the use of tomorrow's multiple-function-on-a chip ICs. Jim Lang, Fairchild Semiconductor, So. San Jose, CA.

NSC800 In Low-Power Systems. Uses new high-density CMOS process called P²CMOS. An 8-bit CPU and supporting components are covered. Keith Winter, National Semiconductor, Santa Clara, CA.

Design and Use of Mostek PROM Programming Unit. Applies MK3873 single-chip microcomputer. Don Folkes, Mostek, Carrollton, TX.

The CONCEPT-48 Development Tool. Single-board system for 80C48 family. Gopal Ramachandran, Intersil, Cupertino, CA.

Z80 As a Versatile Communications Device. Z80 FIO as used in BiSync, HDLC, and SDLC communications protocols. James Booth, Mostek, Carrollton, TX.

PALs Replace Random Logic in Microprocessor Designs. Use of PAL series 20 to replace 7400 series MSI/LSI devices in microprocessor applications. Saeed Kahmi, Monolithic Memories, Sunnyvale, CA.

NS16000 Supports Virtual Memory. Virtual memory, a mainframe concept in the past, is applicable to microprocessor-based designs thanks to the 16000 microprocessor. Su Bhash Dal, National Semiconductor, Santa Clara, CA.

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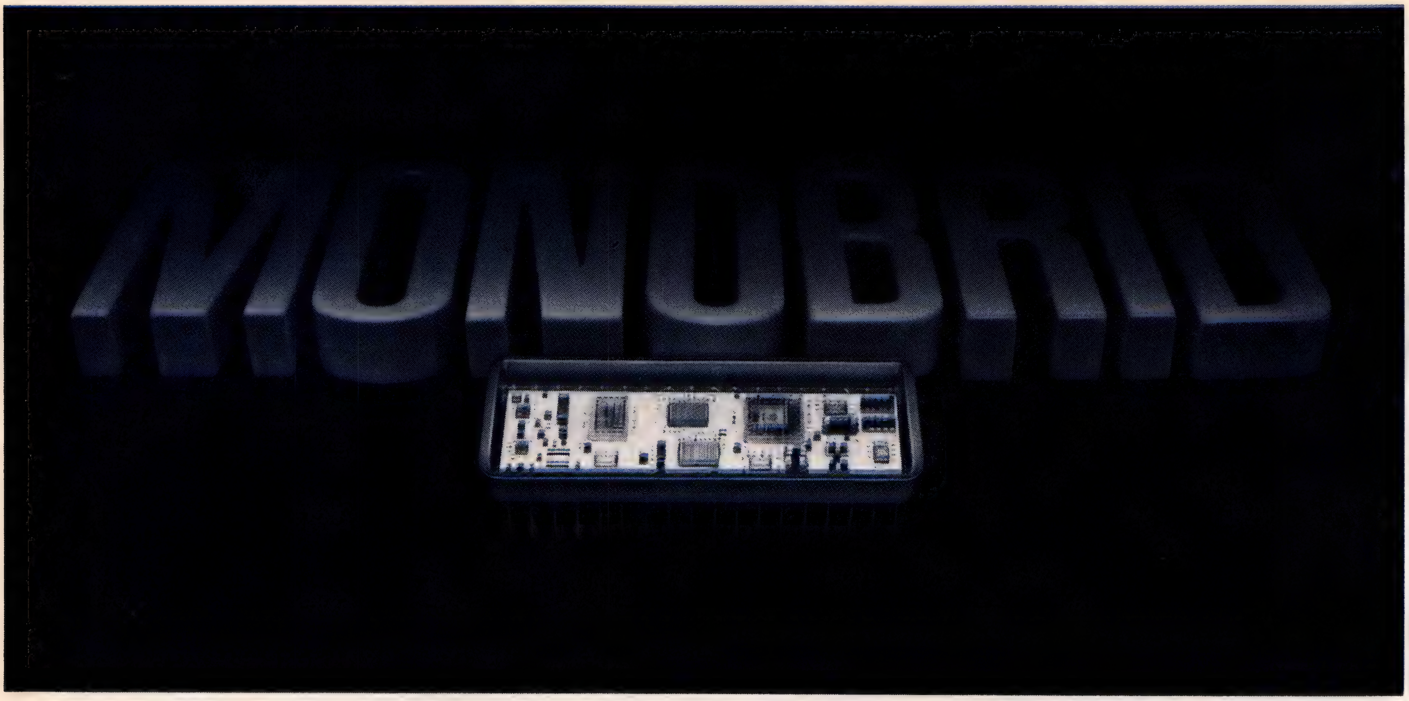

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CIRCLE 52

Products

Spectrum and network analyzers, counters, signal sources and power meters place new-found intelligence and more sophisticated circuits at the convenience of users.

Focus on microwave and rf instruments: High-quality readings come easy

One trend dominates the technology for all active rf and microwave instrumentation—the incorporation of microprocessors or, more broadly speaking, semiconductor intelligence. Smart spectrum analyzers can carry laboratory quality and capability into the field. Network analyzers gain an otherwise expensive ticket to board the IEEE-488 bus. Microwave and rf counters also add on capabilities as they add on microprocessors; for example, the instruments can automatically and directly measure the frequency of pulse-modulated microwave signals. Signal sources are easier to use and have easier access to the IEEE-488 bus. Power meters attain an analytical power that, in some ways, rivals the power of network analyzers—but for many dollars less.

Jonah McLeod, Instruments Editor

The microprocessor has added convenience to spectrum analyzers while improving the quality of readings. The analyzer's main function is to measure the absolute and relative characteristics—both frequency and amplitude—of an unknown signal. To measure relative frequency and amplitude, the operator can read the values shown on the instrument, read a digital value or (in the case of amplitude) read a graticule level, and then perform a subtraction. Many errors can occur in the process, including misreading the graticule levels, faulty interpretations or incorrect subtraction. All these problems are solved with the aid of a microprocessor.

A microprocessor-assisted phase-locked loop in the Tektronix Model 492 gives assurance that the spectrum analyzer will remain on frequency. The local oscillator in the $18,000 instrument covers the frequency range from 1 to 6 GHz.

Because Boonton's rf wattmeter accepts a second input channel, it can display either one of two inputs or their instantaneous difference, expressed in dB. Thus, the operator gets two power meters in one unit.

Microprocessor drive in the Bird 4381 power meter makes it a snap to measure incident and reflected power and display values directly in watts or dBm. However, its real impact on power measurement is to improve overall accuracy and repeatability.

After the operator "marks" the two signals that must be compared in frequency and amplitude, the microprocessor does the rest, up to and including the subtraction. Hence readings are easier to make, more accurate and completely consistent, regardless of how many operators make the same reading.

Analyzers with microprocessor conveniences currently include the Hewlett-Packard (Palo Alto, CA) 22-GHz 8566A, costing $49,000, and the Tektronix (Beaverton, OR) 21-GHz Model 492 (Electronic Design, Jan. 4, 1980, p. 34), which sells for around $18,000. In both products, the microprocessor also plays a role in the instruments' phase-locked loops. In the Tektronix implementation, the microprocessor monitors the error-correction voltage that acts as feedback in the loop. When the μP detects the voltage level rising to a maximum, it indicates that the oscillator is about to break lock, and it automatically retunes the oscillator toward the correct frequency. As the frequency approaches the correct value, the phase-locked loop reduces the error voltage accordingly.

A similar capability is found on the Hewlett-Packard unit, in a feature called "sweep and lock." In addition to preventing loop drift, the microprocessor checks for excessive oscillator drift in the unit's synthesized front end, during each sweep of the CRT display. Then, during the retrace interval, the microprocessor moves the oscillator back by the amount of detected drift.

Besides these subtle improvements, the microprocessor in the HP unit takes credit for a bevy of other operator conveniences: automatically finding the highest amplitude signal in a spectrum, saving the instrument's control-setting configuration for later automatic reconfiguration, and computation. The microprocessor can process so much data, the operator may never again need to do mental or physical arithmetic.

Oscillator widens input frequency range of analyzer

While microprocessors have improved the spectrum analyzer considerably, the front end and mixer circuits have also contributed technological advances. One innovation is in local-oscillator circuits. Most analyzers use a conventional 1 to 4-GHz circuit; however, the Hewlett-Packard and Tektronix units use a wide 1 to 6-GHz design. Foremost among the advantages of the 1 to 6-GHz oscillator is that an analyzer can handle a wider input frequency range.

Most analyzers use a harmonic mixing technique, in which the incoming signal is heterodyned with a harmonic of the local oscillator signal, rather than the fundamental frequency. Consequenty, in the narrower 1 to 4-GHz design, the mixing of a 40-GHz signal requires a distant oscillator harmonic that is apt to be low level, relatively unstable and inaccurate. The broader, 1 to 6-GHz signal can do its job with a harmonic at a much lower frequency. This harmonic is apt to have a higher signal level, relatively more stability and more accuracy as well.

In the past, analyzer engineers were kept from adapting the wide-range oscillator by a design riddle: By what means could they tell if the in-range fundamental frequency were the true signal or the second harmonic? For example, the second harmonic of 2 GHz is 4 GHz, a fundamental frequency which also falls in range. How both HP and Tek got around the problem is their secret, but Morris Engleson, Tek's Marketing Manager for frequency-domain instruments, says that the instrument "simply ignores" harmonics in the fundamental range—an understatement to say the least.

Although the Tektronix unit brings laboratory accuracy into the field, the Hewlett-Packard 8566A laboratory instrument takes precedence in this instance by virtue of three specifications. The first of these is frequency accuracy, a startling 0.2%—the HP instrument exhibits errors of a few kilohertz where other analyzers show megahertz errors.

The second specification is 3-dB resolution bandwidth—a narrow 10 Hz. The closest rival to the 8566A is the Tektronix unit at 50 Hz. The third specification is sensitivity, which is better than −134 dBm over a non-preselected range of 1.0 MHz to 7.5 GHz. Again, the Tek unit comes close, with better than −125 dBm.

In one specification, however, the older HP unit falls behind the newer Tek instrument—total frequency range. The Tek analyzer is fully calibrated for 60-GHz operation using Tek's own mixer option, and 220 GHz using mixers from other suppliers. By comparison, the HP unit, at present, stops at 22 GHz.

The spectrum analyzers of other companies bring their own competitive weapons into the field. From Ailtech Electronic Instruments (Ronkonkoma, NY), a division of Eaton Corp., comes the 757, which introduces internal frequency and amplitude calibration, based on an integral 100-MHz comb generator. In exact 100-MHz multiples over the entire 22-GHz range, the generator provides calibration signals to ensure the instrument is correctly calibrated at all times. A front-panel indicator lets the operator know if the unit is incorrectly calibrated.

A second improvement incorporated onto the latest version of the 757 is an arithmetic capability that normalizes a measurement to the actual test setup in use. All mismatch errors are prevented. The 757 also features digital storage, for a flicker-free display: complete readout of analyzer control settings on the CRT screen; and 100-dB on-screen dynamic range.

In the Polarad (Lake Success, NY) 600 series of spectrum analyzers, three technological improvements are in evidence. In the A version of the analyzer family, a balanced input mixer in the front end has advanced sensitivity to −120 dBm, with a noise floor equal to or less than −126 dBm. The entire

Before Hewlett-Packard's 5356C frequency-converter head became available for its 5345A counter, the upper limit for pulse-modulated frequency counting was 18-GHz. Now, 40 GHz is easily achieved.

Related to the network analyzer, the Weinschel Engineering VM-4A attenuator and signal-generator calibration (shown sitting on a tracking local oscillator) impresses with an insertion loss that exceeds 100 dB.

family can analyze frequencies in the range from 10 MHz to 18 GHz; an external waveguide mixer lets the units reach the 40-GHz high end. A sensitive, broadband 10-MHz to 18-GHz stripline input mixer is standard in all models. Response flatness is ±1.5 dB from 10 MHz to 1.8 GHz, and ±2 dB from 1.8 to 2 GHz.

Marconi Electronics Inc. (Northvale, NJ) has a basic 110-MHz spectrum analyzer, the TF 2370, which can be extended to 1.25 GHz via the TK 2373 plug-in. Both instruments boast a 100-dB dynamic range, resolution of 0.1 dB, using a 5-Hz filter, and 200-Hz scan width. A second, more recent product is the TF 2371, which retains all the features of the TF 2370, but extends the frequency range to 200 MHz.

Other new units come from Texscan Corp. (Indianapolis, IN) which offers the AL-51A, and from Takeda Riken Industry Co., Ltd. (Tokyo, Japan), which offers the 1-GHz TR-4132/4132N models.

Scalar network analyzers show better return loss

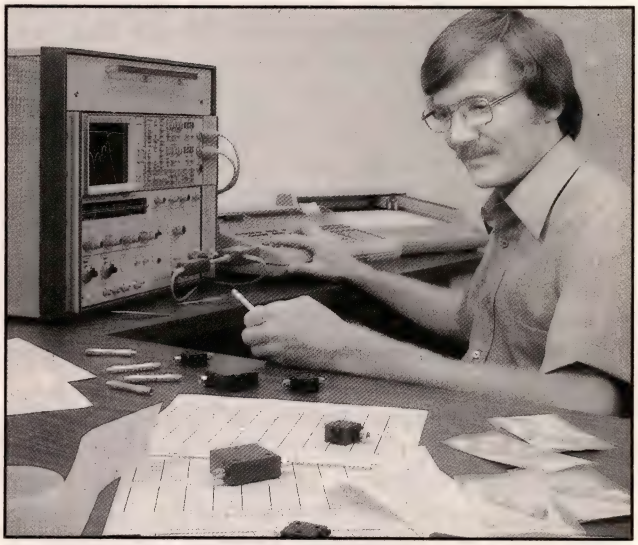
Spectrum analyzers share the limelight with μP-controlled network analyzers, both scalar and vector/scalar models. In the scalar variety, new technology encompasses full IEEE-488 capability (made possible by the μP), integral detectors that extend the analyzer's range to 34 GHz—with significantly better flatness and return loss—and directional couplers with greatly improved directivity over a broad 10-MHz to 18-GHz range.

Scalar network analyzers measure only the magnitude of the signal under test. Here, the key parameters are the detector's frequency response range, its response flatness over the range and the return loss it produces in the signal being measured. Previously, the best range possible on scalar analyzers was 10 MHz to 26.5 GHz. The response flatness was 0.5 dB from 10 MHz to 18 GHz and 1 to 1.5 dB up to the top. The best return loss was 20 dB to 4 GHz, falling to 10 dB at 18 GHz.

All of these limits have now changed. The Wiltron (Mountain View, CA) 560 network analyzer has extended the response range to 34 GHz; its detector provides a flatness of ±1/2 dB to 18 GHz, and ±2-1/2 dB to 34 GHz. Return loss is 22 dB to 8 GHz and 17 dB beyond.

For measuring insertion and return loss, the network analyzer needs a microwave bridge. Technology advances have extended the limit of directivity (that is, the ratio of signal levels reflected and incident waves) in microwave bridges. Before, the limit of directivity was about 38 dB over a narrow range from just below 100 MHz to slightly above 1 GHz. It fell to just under 26 dB up to 18 GHz. On the Wiltron 97 Series Autotester, the directivity remains at its high 40-dB level over the entire range from 10 MHz to 18 GHz.

Alone among frequency-synthesizers, Micro-Tel's FS-1000 offers 100-Hz resolution—two orders of magnitude better than that from most units. Its removeable rf assembly operates in remote locations.



The Wiltron 560 scalar network analyzer extends the upper limit of network analysis to 34 GHz and offers a record 22-dB return loss. The unit was the first of its kind to go on the IEEE-488 bus.

At its introduction, the Wiltron product was the only one available with IEEE-488 capability. Now, Pacific Measurements has announced this feature in the D-14 option to their Model 1038 instrument.

Semiconductor electronics implement the full IEEE-488 bus specifications for both talker and listener. These systems are suited for production lines, for which scalar network analyzers have long had a variety of applications.

Vector/scalar analyzers take phase measurements

Vector/scalar instruments cost more than twice as much as the scalar units but can take phase measurements in addition to magnitude. Because of this added power, the vector/scalar instrument is found in development applications.

Hewlett-Packard manufactures the HP8409B automatic network analyzer, a completely automated network analysis system. The system is a collection of individual instruments controlled by a desk-top computer. The computer gives readings with metrology-lab quality by performing a 12-term error-correction algorithm and completes readings in minutes instead of hours. The 8409B, at about $80,000, is half the cost of the previous generation minicomputer-based system.

The HP8754, recently announced, is an individual analyzer with integral source, receiver and display. It has many of the performance features found on an older network analyzer, the 8505, but at $11,500, is about a third of the cost. The user gets an 80-dB dynamic range (100-dB range in the older product), polar coordinate display capability and a broad frequency range up to 2.6 GHz.

What the user fails to get is the older product's ability to measure the amount of linear phase deviation a signal experienced and to measure group delay directly, i.e., to determine the amount of phase shift experienced by a small group of frequencies within a larger band.

Singularly absent from all of these network analyzer instruments (both scalar only and vector/scalar) is the microprocessor. Discrete logic has taken its place, in the case of the Wiltron unit, and a completely separate computer serves the Hewlett-Packard system. Most instrument makers are now introducing units that were in design one or two years ago, when the right microprocessor was either not available or not a viable design alternative.

A related product does have a microprocessor: the Weinschel Engineering VM-4A attenuator and signal generator calibrator. Operating over a range of 0.01 to 18 GHz, the instrument can be used to measure insertion loss in excess of 100 dB and can optionally make phase measurements with a 0.1° resolution. Controlled by a PACE microprocessor (soon to be changed to an 8080), the instrument has full talker/listener capability on the IEEE-488 bus.

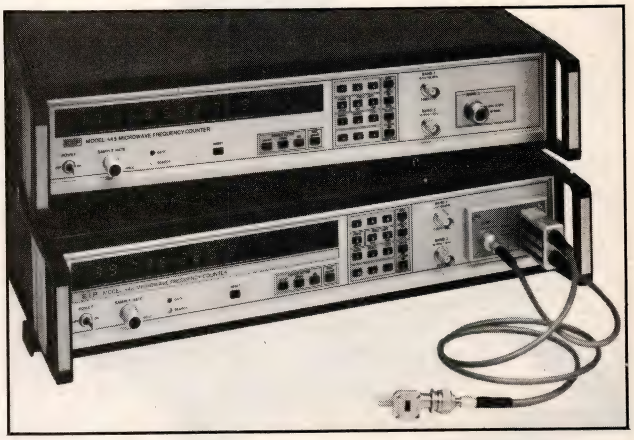
Microprocessors have made greater inroads into microwave counters than into network analyzers. Even so, other technological enhancements are having more impact than microprocessors on counters. The 545/548 microwave counters from EIP Microwave, Inc. (San Jose, CA) integrate a hybrid front-end with mixer, YIG filter and comb generator. The YIG filter, which steps in 100-MHz steps and has a 20-MHz bandpass, provides burnout protection for incoming signals up to 5 W. The front end has a frequency-hunt function which can discriminate a 10-dB difference in incoming signals and select the higher signal. The front end as a whole provides −30 dBm of sensitivity for signals up to 12.5 GHz, slightly more than the −25 dBm heretofore possible. Finally, in concert with the counter's microprocessor, the new front end speeds up measurements, giving a reading with 1-Hz resolution in 1 second.

Though this instrument brings new technology to the field, it is not alone. Hewlett-Packard has the 5345A counter, its associated 5355A automatic frequency converter and the newly announced 5356C frequency converter head. The instruments are also microprocessor-based and have other similarities with the EIP counters. The HP counter can adjust its gate to fit pulsewidths as narrow as 60 ns. Like the EIP product, the HP offering can perform automatic amplitude discrimination to select the highest amplitude signal in a complex spectrum. Furthermore, it also achieves 1-Hz resolution in a 1-second measurement time.

Both EIP and HP counters have IEEE-488 interfaces and options to extend the input frequency range from the previous 26.5-GHz limit up to 40 GHz for CW measurement. HP obtains pulsed rf and CW microwave counting functions through the 55560 plug-in for the 5345A mainframe. The 55560 extends the counter's frequency range for pulse-modulated microwave counting, from 18 GHz to 40 GHz.

The EIP Model 451 microwave pulse counter was the first to count the frequency within a pulse modulated microwave signal but it handles a maximum frequency of just 18 GHz. Another area of difference between HP and EIP counters is in the options offered. For example, the EIP product has a power measurement option which provides 0.1 dBm resolution over the range from 1 to 18 GHz (optionally to 26.5 GHz).

Two other companies with microwave counters are EH international (Oakland, CA) and Systron-Donner



EIP's 545/548 microwave counters offer burn-out protection of up to 5 W, provide a frequency-hunt capability which can discriminate a 10-dB difference between incoming signals, and provide a low, 30-dB sensitivity.

Corp (Concord, CA). From EH comes the Model 992 Microwave Universal Counter, which operates up to 26 GHz (optionally to 40 GHz) in a CW counting mode. It offers a sensitivity of −30 dBm and 2-ns resolution single shot, 20-ps resolution average.

Systron-Donner's 6054 Microwave Series also operates to 26 GHz in CW counting mode, has a −30-dBm sensitivity and a 30-dB dynamic range. Like the HP and EIP units, the counter has 1-Hz resolution in 1 second of measurement time. Both the Systron and EH counters are microprocessor controlled and offer IEEE-488 capability as an option.

Smart chips handle sweep operations

The acceptance of the microprocessor in the counter is equalled by its acceptance in the signal generator. Manufacturers of synthesized frequency sources make heavy use of smart chips in maintaining frequency accuracy, in handling difficult sweeping operations and in interfacing the IEEE-488 bus.

Other semiconductor electronics have a special place in signal generators. At the very high end of the microwave frequency spectrum, beyond 40 GHz, progress centers around the first full-band solid-state millimeter-wave sweep generator. The wide band in the millimeter-wave range is owed to the Hughes (Torrance, CA) Model 4772XH full-band sweep generator. In this product, three IMPATT sources produce a bandwidth up to 110 GHz using the HP8620C mainframe. In the past, millimeter-wave generators had a problem with nonlinear power output; as frequency rose, so did the output power. In the 4772, attenuation is automatically added in the output path to offset the power increases that occur with increasing frequency. Because of this added capability, the user can fully automate millimeter-wave testing under computer control, a feat heretofore impossible.

MICROWAVE UNIT MODEL 7105
THE NARDA MICROWAVE CORP. PLAINVIEW, NEW YORK U.S.A.
MICROWAVE MULTIMETER MODEL 7000A

The Narda Model 7000 is the first "microwave multimeter." Its microprocessor takes over time-consuming computations and performs internal calibrations to ensure instrument accuracy.

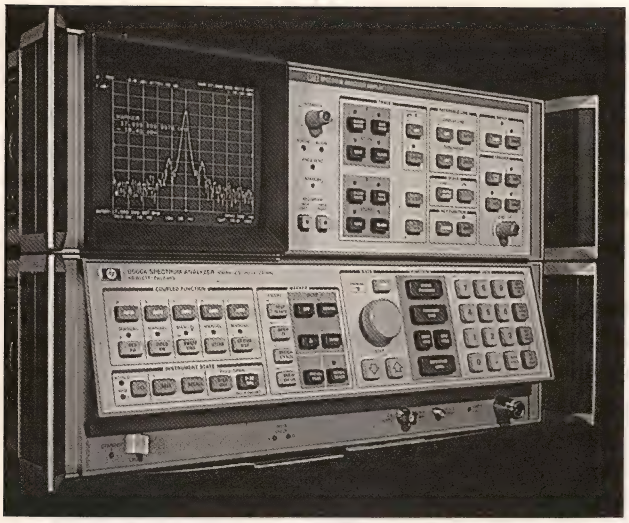
Solid-state has occasioned another technology coup in the signal generator product: the decline of the klystron tube in one of the last strongholds of vacuum tube technology. Wavetek (San Diego, CA) builds a strong case for solid-state by comparing its Model 907 to the Hewlett-Packard HP620B, and established klystron-driven signal generator. Generally, solid-state units operate 10,000 hours, long outlasting klystron (100 hours). Specifically, Wavetek notes that modern radar requires a signal generator with an on/off ratio of at least 80 dB, rise and fall times of 40 ns on modulating pulse edges and a minimum pulse width of 200 ns. Two of these three specifications go in favor of the solid-state unit.

The 907 possesses a 12 to 25-ns rise and fall time, compared with rise and fall times exceeding 50 ns for the tube oscillator. Moreover, the minimum pulse width of the 950 is 200 ns. The tube has a 500-ns minimum, but this can be decreased using an external pulse generator. The klystron has the advantage in its on/off ratio, which is infinite. The solid-state unit offers the minimum 80 dB required.

Another comparison between the two units measures the amount of distortion in power output over each instrument's maximum range of frequency deviation. The solid-state unit provides a more constant level of output power than the klystron.

The solid-state unit also outperformed the klystron in frequency pulling during pulse operation and as a result of attenuation applied to the generator's output. Using a 7-GHz frequency, each unit was pulsed with a 50-Hz square wave. The output frequency from each generator was sampled at a 500-μs rate to determine the frequency drift within the output pulse. The solid-state unit showed little frquency pulling (50 kHz), but the klystron unit drifted 500 kHz. A similar result accompanied changes in each generator's output attenuator.

While this comparison shows the solid-state design besting the klystron in several areas, some words of caution are in order. The solid-state unit uses a YIG-tuned Gunn diode oscillator. One of the criticisms leveled at this circuit by klystron proponents is that it has an inherent drift problem because of magnetic field dissipation. However, from the



Hewlett-Packard's 8566A spectrum analyzer boasts a 0.2% measurement uncertainity, a 3-dB resolution bandwidth of 10 Hz, and a 134-dBm sensitivity over a nonpreselected 1.0-MHz to 2.5-GHz range.

specifications cited for the solid-state 907, this problem has been addressed in the design.

Klystron proponents also point out that attenuation in a solid-state design is typically accomplished using series pin-diode attenuators in the output. Because the pin devices are made of semiconductor material, their output accuracy is affected by time and temperature. The specifications for the 907 seem to confirm this problem: The klystron-driven generator has a ±2-dB accuracy over the range −7 to −127 dBm, but the solid-state unit has just ±6-dB accuracy over the range −80 to −127 dBm.

Another supplier of klystron-driven signal generators is Polarad. Its product offering, the Model 1107E/BE/C/CE, borrows heavily from solid-state technology—the bulk of the instrument is solid state—while maintaining its tie to proven vacuum-tube technology. The unit's oscillator is a reflex klystron in an external coaxial resonant cavity. The product features low noise sidebands, high spectral purity and stability, a dynamic range exceeding 130 dB, and a very high pulse and square wave on-off ratio.

Two classes of related products are the signal source and high-power signal generator. Marconi Instruments Ltd. (Northvale, NJ) produces the 6150 Series AM-FM signal sources. Like the Wavetek generator, this product is all solid-state. Its active rf element is a YIG Gunn oscillator. All its AM functions are performed by a pin modulator fitted to the signal source. It controls the instrument's output level over a 20-dB dynamic range and can apply AM either from the instrument's internal 1-kHz squarewave modulation circuit or from an externally supplied AM source. The instrument spans a frequency range of 8 to 15 GHz and puts out 20 mW of power typically.

High-power signal generators include the Cober Electronics, Inc. (Stamford, CT) Model 1326 and the MCL/Inc (La Grange, IL) Model 15222. The former puts out 500 W CW and 1.8 kW pulsed, using air or liquid-cooled magnetrons over a frequency range of 350 MHz to 10.475 GHz. Operating at a lower 100-W power level, the 15222 spans a 10 to 2.5-GHz frequency range, using a series of oscillator plug-in units that mate with an all solid-state mainframe.

Signal generators in the rf band have been quicker to embrace the microprocessor than their microwave cousins. Prime examples are the new Hewlett-Packard 8656, the company's older 8662A and the Ailtech (Ronkonkoma, NY) Model 460 and 380.

One of the key attributes of the HP8656 is its microprocessor. Functionally, the unit serves as a lower performance, lower cost version of the company's high-performance 8662. The newer product, which goes for $6250, is less than a third the cost of the older unit and has an array of operator features that make it extremely well suited for production-line testing.

For example, frequency, AM or FM modulation and output power are keyed in directly in the units desired, e.g., MHz, dBm, dBf (for broadcast stereo applications) or EMF. For the production-line application, the instrument can store and recall up to ten front panel setups (five test setups) each of which can be recalled by pushing two buttons or depressing a foot pedal.

Specifications for the unit include sideband phase noise at 225 MHz of −122 dBc/Hz with a 20-kHz offset. Output from the instrument exhibits harmonics less than −25 dBc, and nonharmonic spurious output is less than −60 dBc. Output level ranges from ±13 dBm to −127 dBm with ±1.5 dB accuracy and ±0.1 dB resolution.

The Ailtech 460 and 380 signal generators are both microprocessor-based. The 460 is the newer of the two; it operates over a lower frequency range, 0.3 to 650 MHz (optionally to 1.3 GHz). The 380 goes up to 2 GHz (optionally to 4 GHz). The 460 shows high spectral purity, accuracy of $\pm 1 \times 10^{-8}$ over 24 hours and an output level of +20 to −140 dBm in 1-dB steps.

The 380 features low noise with spurious signals, less than −100 dBc at 80 MHz and less than −74 dBc at 2 GHz with a broadband noise floor of less than −130 dBc. The unit also has a switching time of less than 20 μs, and a microprocessor that performs digital sweeping, store recall and many other front-panel operator functions.

Wavetek's entry in this field is the Model 3010 which goes to 1 GHz in output frequency, offers 100-Hz resolution, 0.001% accuracy, 13-dBm output, an output power range of +13 to −137 dBm with a flatness of ±0.75 dBm, and a flexible modulation capability. The instrument can provide complex, or simultaneous, modulation: AM on FM, FM on PM or AM on AM.

The Systron-Donner Model 1702 offers specifications similar to those of the Wavetek 3010. With 100-Hz resolution, the unit has an output power range of +13 to −127 dBm with a flatness of ±1 dB. An IEEE-488 interface capability is optional.

Signal sources and generators have still another relative in the frequency synthesizer, which has made extensive use of the microprocessor. Micro-Tel Corp. (Baltimore, MD) has its FS-1000 frequency synthesizers, Watkins-Johnson (Palo Alto, CA) has the UJ1250A unit, and Hewlett-Packard has the HP8672A. The microprocessors on these instruments program the unit with a stop frequency, a band of frequencies that must be stopped and the length of the stop at each frequency in the band. On the Watkins-Johnson and Micro-Tel units, the microprocesser is controlled from the front panel; the HP unit handles the task via the IEEE-488 bus.

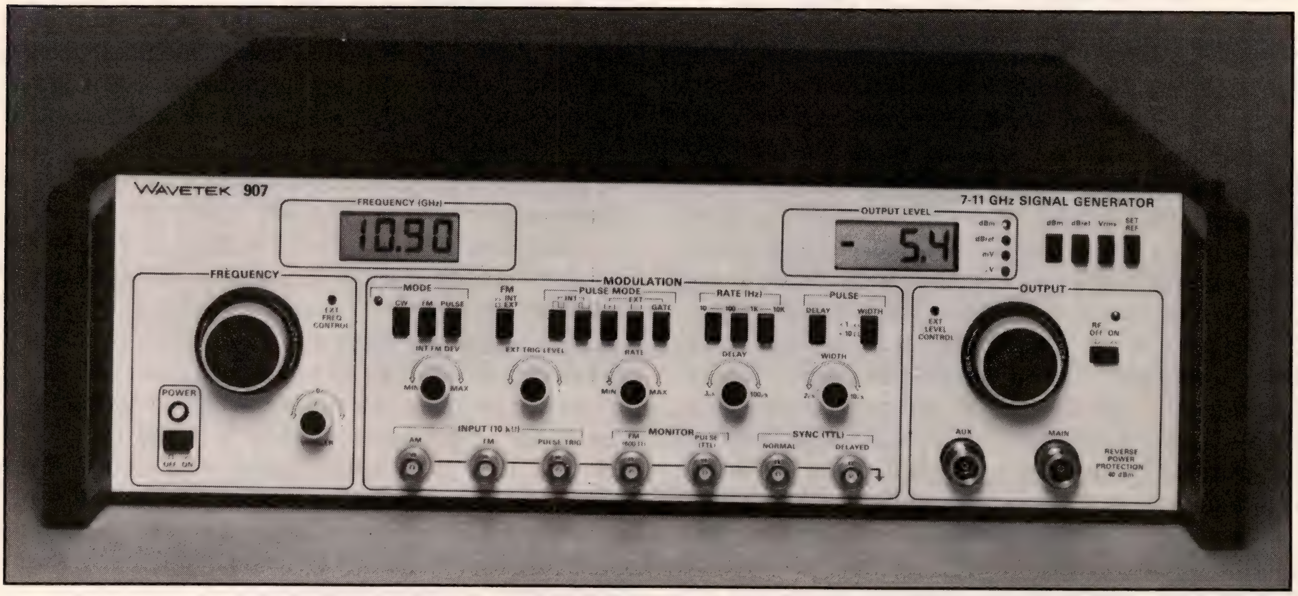
The Micro-Tel unit offers an optional 100-Hz resolution with 10-kHz standard. HP's product has a standard 1 to 3-kHz resolution over the frequency range and the Watkins-Johnson instrument comes in with 100-kHz resolution. The typical frequency range for microwave synthesizers stops at 18 GHz; however, options can extend the range to 40 GHz. Switching times are typically over 40 ms, but the HP unit switches in 15 ms.

Finally, the ubiquitous microprocessor has burrowed into the microwave power meter. The μP-based power meter provides measurement values that the operator previously had to derive himself. Measurement values like incident and reflected power are displayed in watts or dBm. Voltage standing wave ratio (VSWR), return loss, reflection coefficient, insertion loss and gain are all available at the press of a button.

More subtle features made possible by the microprocessor appear on the Bird Electronics Corp. (Cleveland, OH) Model 4381. The microprocessor senses the nonlinearity of the instrument's own power measuring head. It interpolates, via a software lookup table, to linearize the head—a time-consuming task previously done by the operator. Thus, the instrument not only makes the operator's task easier, it also makes his readings more accurate and repeatable.

The instrument measures peak envelope power, operates on a battery, displays changes in power level using greater-than and less-than symbols in the display and will soon have an IEEE-488 interface for data logging functions.

Narda Microwave Corp. (Plainview, NY) furnishes several notable features in its Model 7000, which is both a power meter and the first microwave multimeter. The microprocessor inside adds accuracy to the instrument by automatically linearizing the oscillator. The instrument is versatile, too. For example, simply adding a high directivity bridge (for under $5000) creates an accurate unit for scalar network analysis in field, laboratory or production



Wavetek's Model 907 signal generator uses a YIG-tuned Gunn-diode oscillator instead of the conventional klystron tube. Some of its features are not possible with the older technology—like a 12 to 25-ns rise and fall time in the pulse mode, compared with 50 ns for the tube.

applications.

The Boonton Electronics (Parsippany, NJ) Model 4200 accepts a second input channel and displays either one of the two inputs or their instantaneous difference expressed in dB. Thus, the operator gets two power meters in one package that can directly measure both insertion loss and reflection coefficients. The 4200 automatically zeros itself, has an autoranging standard and calibrates itself against its own 50-MHz power reference. As options, it interfaces to IEEE-488 and has battery operation.

Another supplier of digital power meters is Pacific Measurements, Inc. (1036 and 1037 power meters). Related products include the newly announced Ballantine Laboratories, Inc. (Boonton, NJ) programmable rf millivoltmeter, the 1.2-GHz model 3440A.□

Need more information?

For more information on microwave and rf instrumentation, readers may consult manufacturers listed here by circling the appropriate numbers on the reader-service card. Space limitations prevent listing more vendors, but ELECTRONIC DESIGN's GOLD BOOK provides a comprehensive breakdown by type for both domestic and foreign manufacturers.

Ailtech, 2070 Fifth Ave., Ronkonkoma, NY 11779. (516) 588-3600. **CIRCLE 451**
Ballantine Laboratories, Inc., P.O. Box 97, Boonton, NJ 07005. (201) 335-0900. **CIRCLE 452**
Bird Electronic Corp., 30303 Aurora Rd., Cleveland, OH 44139. (216) 248-1200. **CIRCLE 453**
Boonton Electronics Corp., Rte. 287 at Smith Rd., Parsippany, NJ 07054. (201) 887-5110. **CIRCLE 454**
Cober Electronics, Inc., 7 Gleason Ave., Stamford, CT 06902. (203) 327-0003. **CIRCLE 455**
E-H International Inc., 7303 Edgewater Dr., Oakland, CA 94621. (415) 638-5656. **CIRCLE 456**
Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 857-1501. **CIRCLE 457**
Hughes Aircraft Co., Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, CA 90509. (213) 534-2121. **CIRCLE 458**
Marconi Instruments, 100 Stonehurst Crt., Northvale, NJ 07647. (201) 767-7250. **CIRCLE 459**
Marconi Instruments, Ltd., St. Albans, Hertfordshire, England, AL4 OJN. (0727) 59292. **CIRCLE 460**
MCL/Inc., 10 N. Beach, La Grange, IL 50525. (312) 354-4350. **CIRCLE 461**
Micro-Tel Corp., 6310 Blair Hill Lane, Baltimore, MD 21209. (301) 823-6227. **CIRCLE 462**
The Narda Microwave Corp., Plainview, NY 11803. (516) 349-9600. **CIRCLE 463**
Pacific Measurement Inc., 488 Tasman Dr., Sunnyvale, CA 94086. (408) 734-5780. **CIRCLE 464**
Polarad Electronics, Inc., 5 Delaware Dr., Lake Success, NY 11042. (516) 328-1100. **CIRCLE 465**
Systron-Donner Corp., 1 Systron Dr., Concord, CA 94518. (415) 676-5000. **CIRCLE 466**
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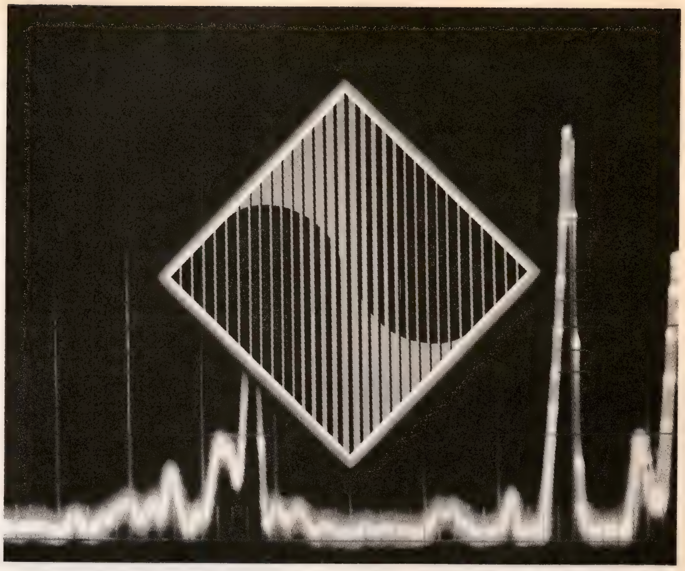
Tektronix, Inc., P.O. Box 1700, Beaverton, OR 97075. (503) 644-0161. **CIRCLE 468**
Texascan Corp., 2446 N. Shadeland Ave., Indianapolis, IN 46219. (317) 357-3184. **CIRCLE 469**
Wavetek, 66 N. First Ave., P.O. Box 190, Beech Grove, IN 46107. (317) 783-3221. **CIRCLE 470**
Wavetek/San Diego, 9045 Balboa Ave., San Diego, CA 92123. (910) 335-2007. **CIRCLE 471**
Watkins-Johnson, 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, CA 94304. (415) 493-4141. **CIRCLE 472**
Weinschel Engineering, Gaithersburg, MD 20760. (301) 948-3434. **CIRCLE 473**
Wiltron, 825 E. Middlefield Rd., Mountain View, CA 94043. (415) 969-6500. **CIRCLE 474**



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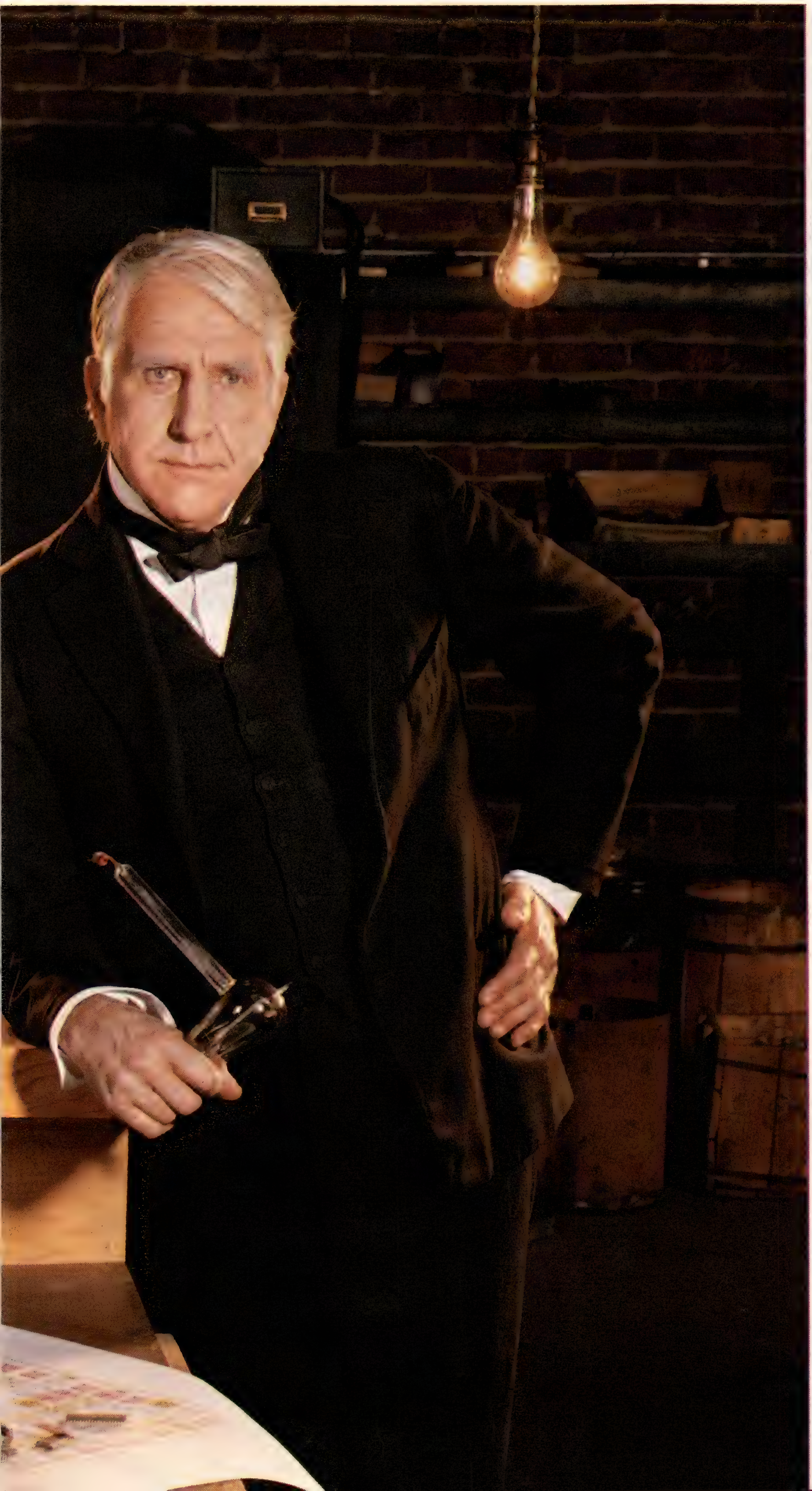

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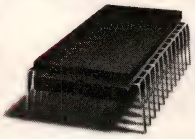

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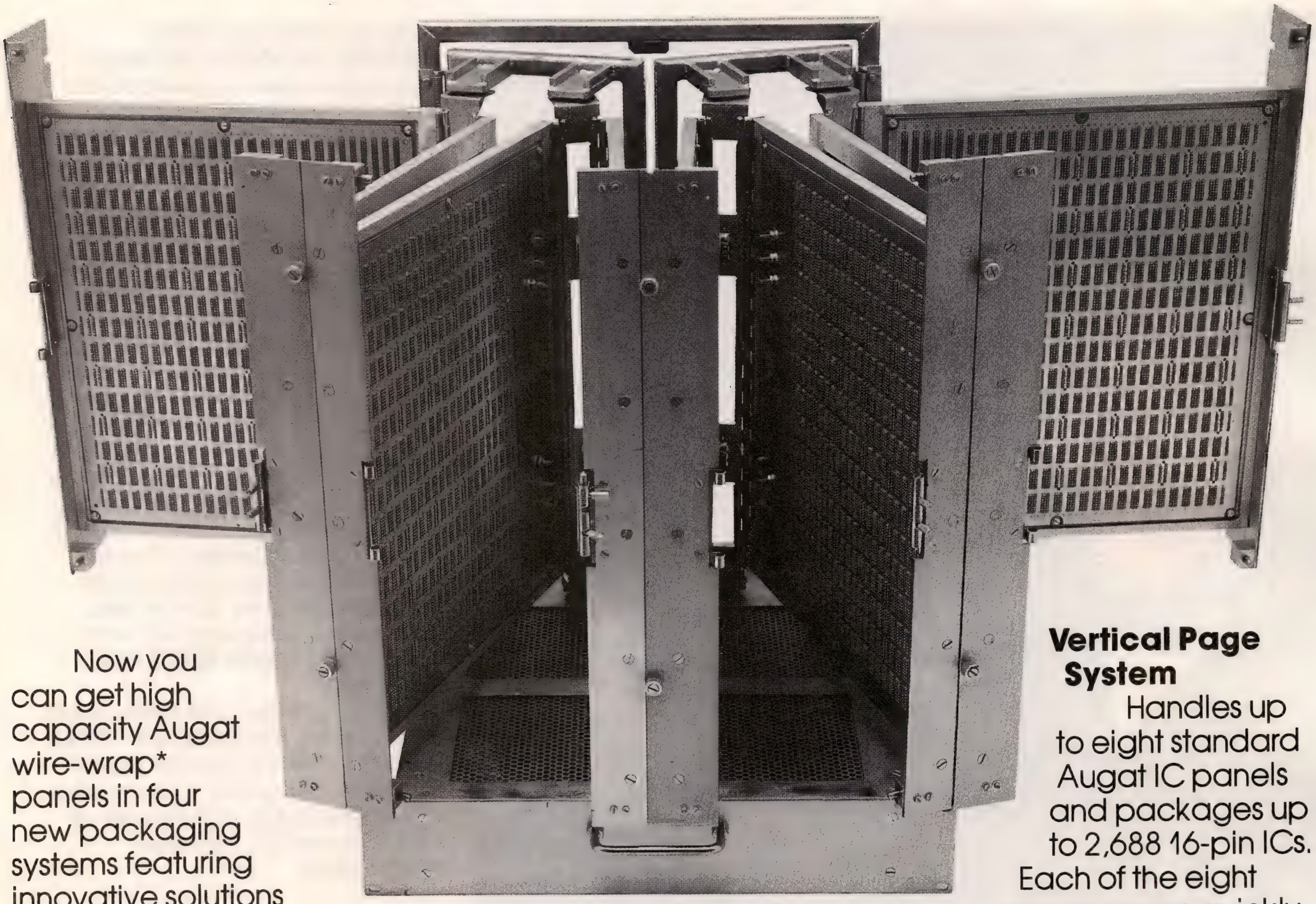

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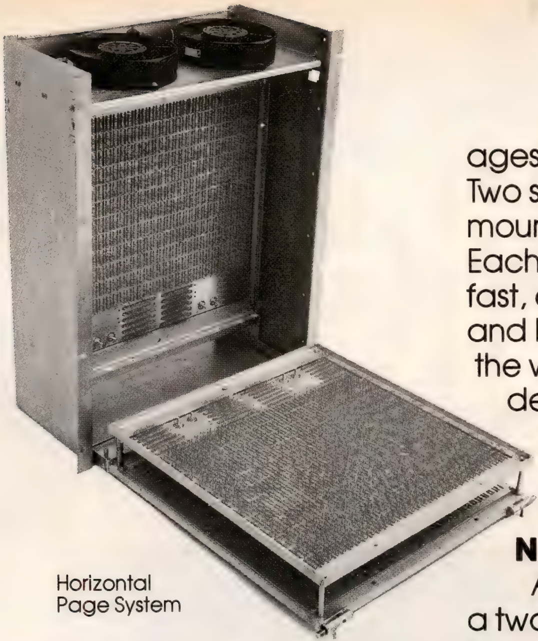

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stitch-wire; and single, double and triple width boards in the same enclosure. Choose either a continuous backplane or three separate backplanes to provide the different voltages and grounds needed to mix analog and digital boards. All are assembled with 96-pin I/O connectors. Flexible spacing lets you use up to four wire-wrap* boards (1.2″ spacing) or 7 stitch-wire boards (.6″ spacing) or a combination of the two. Guide separators let you mix different width boards. Fans are optional.

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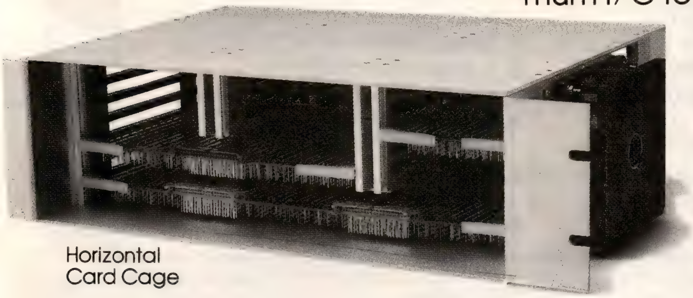

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Kontron Electronics Inc.
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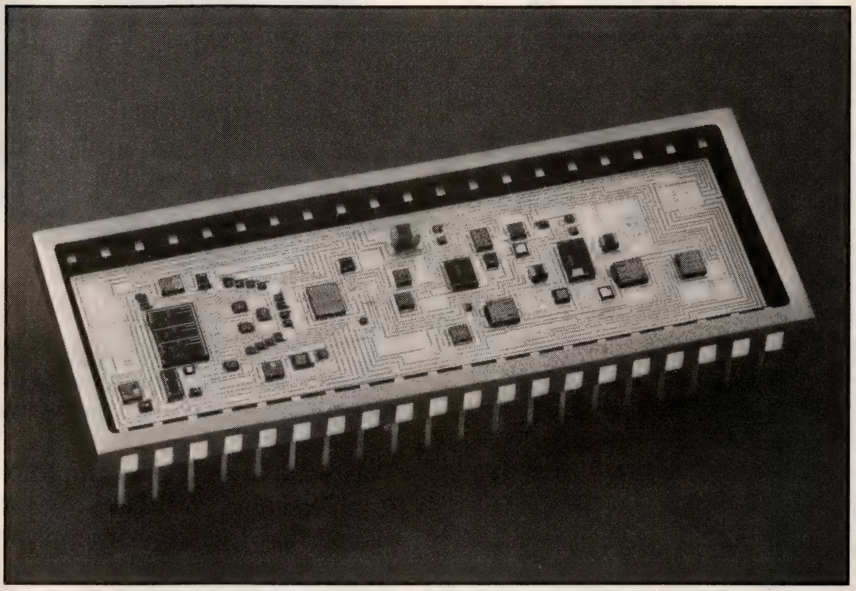
Amtest Associates Ltd.
Tel. 932-5 21 21

Circle 61 for Demonstration

This 12-bit, eight-channel system with a built-in instrumentation amp acquires data at a 20-kHz rate and fits in a standard package.

Data-acquisition system fits in 40-pin DIP



Housed in a double-width, 40-pin DIP, this hybrid circuit packs an eight-channel multiplexer, an address register, an instrumentation amplifier, a track-and-hold amplifier, and a successive-approximation analog-to-digital converter.

Either way, whether packaged as modules or as large odd-sized hybrid circuits, high-reliability data-acquisition systems take up a lot of circuit-board space. To deal with this problem, Micro Networks Corp. has put a hi-rel data-acquisition system—including an eight-channel multiplexer, an address register, a track-and-hold amplifier, a successive-approximation a/d converter and even an instrumentation amp—into a single, 40-pin, double-width (0.600-in.) ceramic DIP.

Moreover, with no external adjustments, the MN7140 H/B provides absolute system accuracy—input to output—within ±0.1% of full scale (±0.05% typical) at 25 C, and easily within ±0.4% (±0.2% typical) over the entire military temperature range (−55 to +125 C). In addition, throughput rate is fast—20 kHz.

Active laser trimming ensures high initial accuracy, eliminating the need for user trims in most avionics applications. Linearity for the entire system is within ±1/2 LSB (±1/4 LSB typical) at 25 C, and typically within ±1/2 LSB over −55 to +125 C. The MN7140 H/B is among the few data-acquisition systems to be fully qualified according to MIL-STD-883B, Method 5008.

Acquisition time for a 20-V step input (through the track-and-hold section, but before conversion) is no more than 10 μs (with 8 μs typical). Analog-to-digital conversion time is less than 50 μs (40 μs typical).

Stephan Ohr, Components Editor

The entire system requires three power supplies: ±15 V for the analog circuitry and +5 V for the logic. Current drain is less than 50 mA from each of the analog supply rails and less than 3 mA from the logic supply. Power consumption for the entire package is less than 1365 mW (908 mW typical).

In addition to the high-reliability system, which sells for $733.50 in hundreds, industrial and commercial versions are available. The MN7140 E/B industrial version includes Class B processing according to MIL-STD-883B, is rated for operation from −25 to +85 C, and is priced at $598.50 in hundreds. The MN7140 commercial version, without hi-rel packaging, is rated for 0 to 70-C operation and costs $309 in hundreds. Delivery time for all three versions ranges from stock to four weeks.

Micro Networks Corp., 324 Clark St., Worcester, MA 01606. Mark Vaughan (617) 852-5400.

CIRCLE 320

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RHOMBUS, for all your impedance matching needs.

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CIRCLE 62

Sample-and-hold amp acquires data in 1 μs

With its 1-μs acquisition time and 5-MHz bandwidth, the TP-4857 is a good choice for deglitching applications and medical scanning equipment.

A sample-and-hold amplifier from Teledyne Philbrick provides a superfast 1-μs acquisition time and is packaged in a high-reliability 24-pin hermetic DIP. Intended for data-acquisition circuits, deglitching applications and medical scanning equipment, the TP-4857 offers a maximum nonlinearity of ±0.002%, a 5-MHz bandwidth and an adjustable droop rate.

The 4857 is an inverting track-and-hold amplifier with an internal buffer amplifier. The addition of a few external resistors permits inverting and noninverting operation, as well as variable gain. A comparator in the amplifier's digital input circuit makes for reliable operation even when a lot of noise is present on the digital ground.

Acquisition time for a 10-V step input to 0.01% full-scale is less than 1 μs (800 ns typical). The sample voltage offset is typically ±1 mV, and the decay rate in the hold mode is typically less than 0.1 μV/μs. A 50-kΩ pot between $\pm V_{cc}$ and pin 3 of the device lets the user trim this decay rate to meet his system requirements.

The gain temperature coefficient of the device is typically below 1 ppm/°C; the sample voltage offset temperature coefficient remains within ±50 μV/°C. Three versions of the amp are offered. One operates from 0 to 70 C (4857), a second works from −55 to +125 C (4857-80) and a third is rated from −55 to +125 C with full MIL-STD-883 qualification (4857-83).

Prices start at $98 each in hundred-unit quantities. Delivery time is eight weeks.

Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, MA 02026. Ted Serafin (617) 329-1600.

CIRCLE 310

Avoid the nightmares in microprocessor design with Pro-Log's STD BUS prototyping system.

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With Pro-Log's STD BUS prototyping system you avoid incompatible parts, overdesigned products, complex instrumentation, software and documentation horrors and highflying costs. The system contains a Z80 or 8085A STD BUS processor card, card rack, power supply, keyboard display card, utility cards, PROM programmer, PROM erase light, system analyzer, PROM-based monitor program with operating and applications software, 2716 PROMs, manuals, program coding forms, maps, instruction books, application notes, and detailed monitor program documentation.

Only $5,800 complete.

From Pro-Log Corporation,
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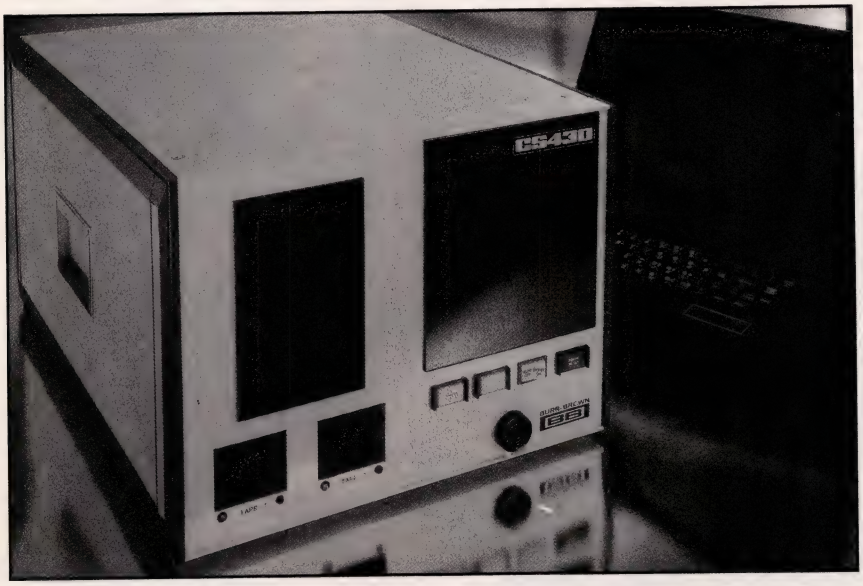
CIRCLE 63

Control system adds on minicassette drives



The CS430 data-acquisition and control system handles 105 differential inputs, 28 analog outputs, and 504 channels each of digital input and output.

A programmable data-acquisition-and-control system has been enhanced with minicassette tape drives suitable for rugged industrial environments, in which floppy disks could present problems.

The two minicassette drives are the only mass-storage elements on the new CS430 controller from Burr-Brown (Tucson, AZ). The earlier CS450 comes with standard 5 1/4-in. diskettes and offers minicassettes as options.

As a production tool, the CS430 acquires extra user memory by eliminating floppy overhead. Out of the available 64 kbytes of RAM, the CS430 yields about 32 kbytes for user programming, compared with about 28 kbytes for the CS450 with diskettes.

Both systems are 8080-compatible and are equipped with Intel's Multibus. The Multibus lets the user mix peripherals and up to seven I/O boards. Both machines operate with an extended Basic—Basic-400—that includes line editing and program tracing and a high-level extended I/O set to simplify their use.

The analog and digital I/O includes up to 105 differential, or 217 single-ended, high and low-level analog inputs; up to 28 channels of analog output; and up to 504 channels each of digital input and output.

The 12-bit analog input boards each provide 15 differential or 31 single-ended channels. On-board software-programmable instrumentation amplifiers offer 11 discrete gains between 1 and 1024.

Both CS430 and 450 systems are available as desktop or 19-in. rack packages, and support Centronics 730 and P1 printers as options.

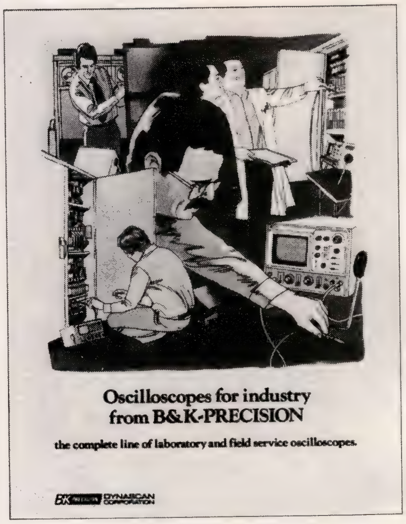
The basic CS430 costs $6750; the CS450 costs $7855. I/O boards cost about $500 each. Delivery is 60 days.

Burr-Brown Research Corp., P.O. Box 11400, Tucson, AZ 85734. (602) 746-1111.

CIRCLE 306

if someone beat you to the B&K-PRECISION 16 page oscilloscope selection guide

that was in this copy of Electronic Design, don't get upset!



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CIRCLE 64

If you can answer these questions, you must be designing in transient protection with GE-MOV® II varistors

Q: Why do I have to protect my solid state circuits from transients?

A: Damaging high voltage transients can attack your circuits through the power line, telephone lines, data lines or by current switching in inductances. They can damage expensive power semiconductors, microprocessors and other digital circuitry. Proper transient protection is essential in circuits designed for reliable, low downtime operation.

Q: How *should* I protect my circuit?

A: A metal oxide varistor provides reliability without requiring overrated semiconductor devices which add to circuit cost. More designers specify GE-MOV® II varistors than any other component specifically designed for transient protection. GE-MOV® has proven cost effective even in the cost-conscious consumer television receiver industry.

Q: What is a GE-MOV® II varistor?

A: The GE-MOV® II varistor, introduced by General Electric in 1972, is a voltage dependent, symmetrical resistor which when exposed to high energy voltage transients changes its impedance from a very high standby value to a very low conducting value, thus clamping the voltage to a safe level. The dangerous energy of the incoming high voltage transient is absorbed by the GE-MOV® II varistor, thus protecting voltage sensitive circuit components.

Q: Won't the addition of a GE-MOV® II varistor add to the cost of my circuit?

A: The answer is threefold—

1. Using a GE-MOV® II varistor eliminates the need for over-rated components and their additional costs to protect from transients.
2. In an improperly protected circuit, a voltage spike can damage a microprocessor or integrated circuit, that usually costs more than the GE-MOV® II varistor, and causes system shutdown and servicing, which usually costs more than any of the components involved.
3. Isn't the reliability of your product worth 56¢*? You can protect your circuit and help protect your company's name with a GE-MOV® II varistor.

Q: How do I select the proper GE-MOV® II varistor to protect my circuit?

A: First: the varistor should have a peak operating voltage rating that is close to, yet higher than, the normal peak ac-line voltage. Next, determine the energy level of the transient by the term $\frac{1}{2} LI^2$ where I is the peak magnetizing current flow in inductance L, which stores the transient energy in its field. Use the peak current as the expected transient current level. Then select the proper GE-MOV® II varistor from the GE Transient Voltage Manual or Short Form Catalog.

For selection assistance contact your General Electric electronic component sales office, authorized distributor or write General Electric Company, West Genesee Street, Mail Drop 14, Auburn, New York, 13021 or call (315) 253-7321, extension 283.

*Price based on a V130LA10A in quantities of 10,000.

222.25

GE makes the big difference in semiconductors

GENERAL ELECTRIC

CIRCLE 79

Dual-channel amp matches precision specs

One problem plaguing dual-channel precision op amps has been the inadequate tracking between amplifiers. In the OP-220 from Precision Monolithics, however, all the precision specifications of one channel are tightly matched with those of the other.

For example, the offset voltages for each channel, which are specified at 100 μV at 25 C, will track each other to within 1 μV/°C. In addition, input bias current is on the order of 20 nA.

The dual-channel amp can operate from a single supply voltage in the range of 3 to 30 V. Supply current is typically around 85 μA, which makes the OP-220 a good choice for battery-powered equipment.

In addition, the OP-220 has an open-loop gain of 1-million with a bandwidth of better than 150 kHz. And noise is rated at less than 50 $nV/\sqrt{Hz}$.

Delivery is from stock to three weeks.

Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, CA 95059. Tom Schwartz (408) 246-9222. **CIRCLE 309**

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Our microwave modules are manufactured with primary seals in the body material itself. That not only improves yields significantly, it also cuts costs. There's no problem with glass seals on thermal cycle and thermal shock reliability tests. And the body of the part is coined, not machined, for greatly improved dimensional stability.

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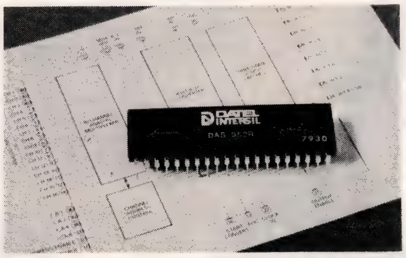
CIRCLE 65

One chip accesses 16 analog channels

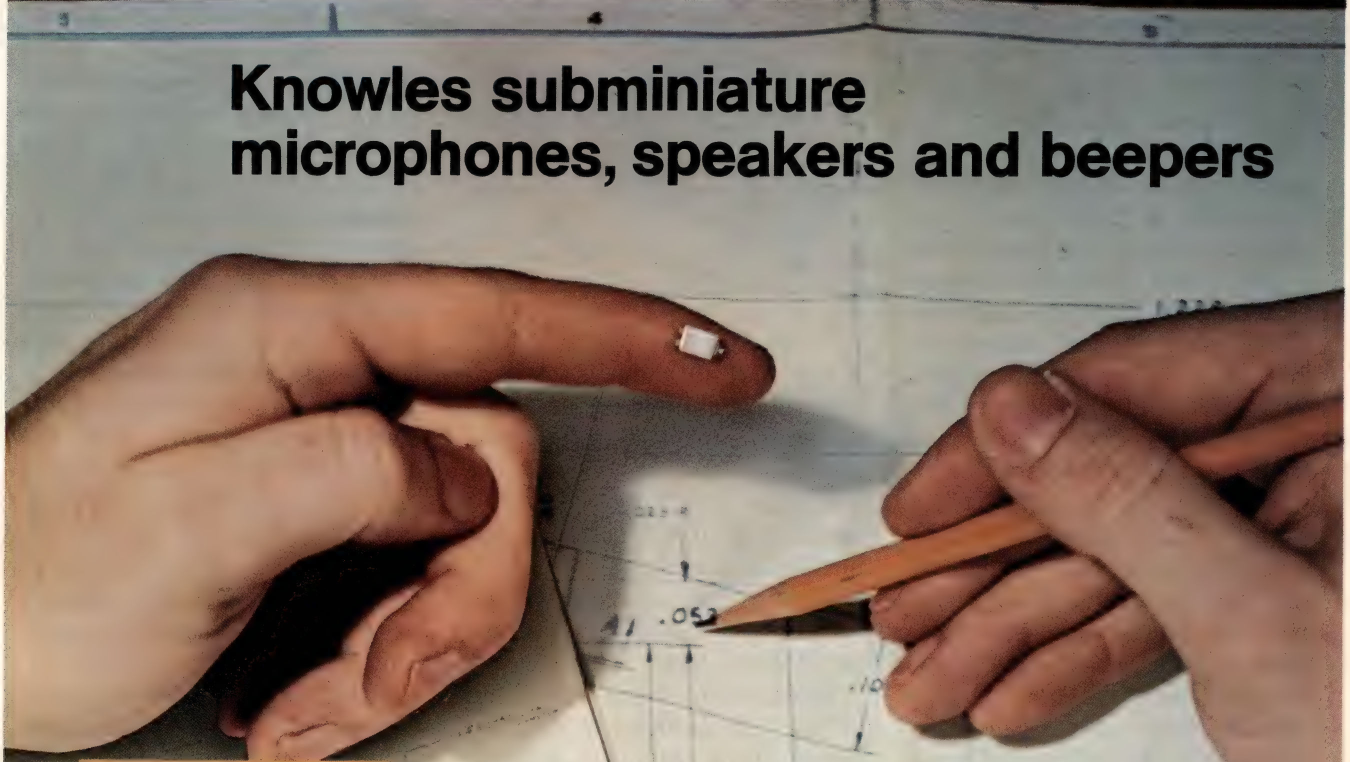


A single-chip, 8-bit data acquisition system, DAS-952R, allows any one of 16 single-ended channels of analog information to be selected and digitized at system throughput rates of up to 17.5 kHz. The 40-pin DIP requires only an external reference, clock and 5-V supply. Total unadjusted error for the system is ±1/2 LSB maximum. The input multiplexer allows direct access to any of the 16 inputs and provides the necessary logic to permit channel expansion. Full-scale range is determined by the external reference, which may be selected to yield a full-scale range of 0.512 to 5.25 V for a LSB size from 2 to 20.5 mV.

Datel-Intersil, 11 Cabot Blvd., Mansfield, MA 02048. Sumner Eagerman (617) 339-9341. $37.50; stock. **CIRCLE 399**

UNMATCHED

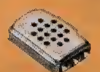
Knowles subminiature microphones, speakers and beepers



MICROPHONE

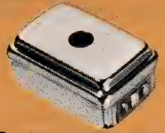
EA SERIES 4.00 x 5.59 x 2.28 mm
(.158 x .220 x .090in.)

DIRECTIONAL MICROPHONE



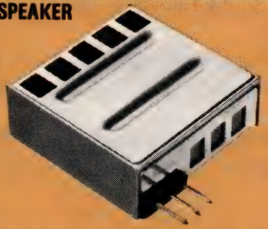
BW SERIES 7.92 x 5.59 x 2.28 mm
(.312 x .220 x .090in.)

BEEPER/SPEAKER



BS SERIES 19.25 x 12.95 x 9.10 mm
(.758 x .510 x .358in.)

SPEAKER



CB SERIES 25.15 x 25.40 x 9.65 mm
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Design flexibility is virtually unlimited when you utilize one of Knowles 30 basic acoustic transducer designs available in over 300 customized variations in the design of your communication device. Universally used in the hearing aid industry since 1946, Knowles subminiature acoustic devices are now being used in telephone headsets, tape recorders, dictating machines, paging devices, radio intercom systems and similar communication products.

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Investigate the advantages of using Knowles subminiature microphones, speakers and beepers in your product. They are available in quantity to OEM users at competitive prices. Delivery schedules are rigidly maintained to facilitate your production planning. Contact us for more information.

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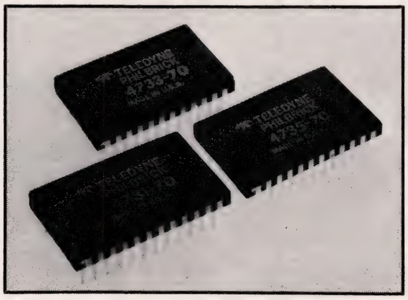
CIRCLE 66

Ceramic DIPs cut v/f converter costs

By using ceramic dual-in-line packages instead of hermetically sealed metal packages, Teledyne Philbrick saves up to 45% of the cost of its hybrid voltage-to-frequency converters, yet sacrifices very little in performance. Although they cost less, the 4731-70, 4733-70 and 4735-70 v/f converters offer the same high linearity, wide dynamic range and low drift as the metal-packaged 4731, 4733 and 4735 converters. However, the -70 devices operate from 0 to 70 C; the other units work from −55 to +125 C.

The 4731-70 provides a full-scale output frequency of 10 kHz; the 4733-70 provides 100 kHz; and the 4735-70 goes as high as 1 MHz. Input voltages range from ±10 μV to ±20 V for a dynamic range of 126 dB. Input current can be as low as 1 nA. The untrimmed input offset is typically ±1 mV.



The 4731-70 and 4733-70 converters offer maximum nonlinearities of 0.005% of full scale, plus 0.005% of the signal. The nonlinearity of the 4735-70 is specified as 0.025% of full scale plus 0.025% of signal.

The ceramic-packaged converters cost from $75 to $95 each in 100-piece lots.

Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, MA 02026. Mitch Bloom (617) 329-1600.

CIRCLE 308

DTMF encoder mates with low-cost keyboards

An improved DTMF encoder chip, ICM7206C operates with inexpensive single-contact calculator-type keyboards. The CMOS chip's oscillator disable function provides for output switch operation only when a key is pressed; no spurious sidetones are generated. The chip interfaces with 4 × 3 or 4 × 4 single-contact keyboards. Output distortion is only 2 to 3% with simple filtering. The device operates from supply voltages as low as 3 V and dissipates less than 5.5 mW at 5.5 V. Only nine additional components, including a common 3.57-MHz color-burst crystal, are required to create a low-cost tone generator.

Intersil, 10710 N. Tantau Ave., Cupertino, CA 95014. (408) 996-5000. $3.41 (100 qty).

CIRCLE 404

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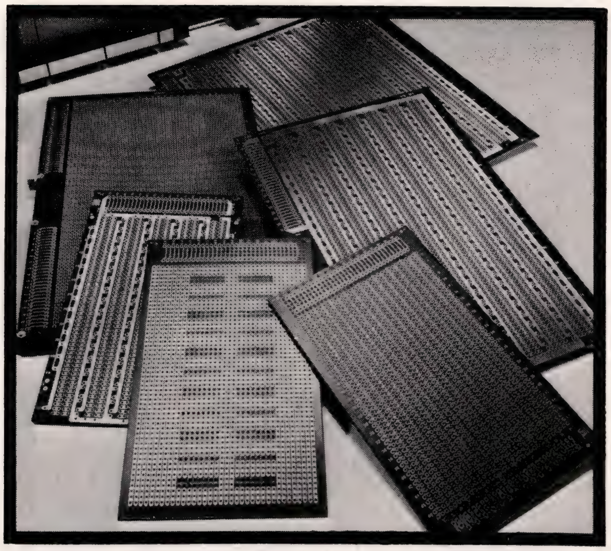
What is a Eurocard?—A Eurocard is a preferred standard circuit board size, very widely accepted throughout Europe and the U.K. It covers 4 preferred sizes, & is compatible with DIN connectors.



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CIRCLE 67

Silent Partners.

Signetics' new dual op amps. Team them with your design for the industry's lowest noise.

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Our new duals combine the industry's lowest spectral voltage with a 600Ω output drive capability. The Signetics 5532 really shines at $6\text{nV}/\sqrt{\text{Hz}}$. And our 5533 brings it all home at $4.5\text{nV}/\sqrt{\text{Hz}}$.

Compare our monolithic pair to other "low-noise" op amps, and see what you've been missing. Like wide power bandwidths at exceptional slew rates.

Use them in your new design. Or specify them as superior replacements for not-so-low-noise op amps you may be using now.

Both devices give you a small-signal bandwidth of 10MHz, and high output drive capability. *By "high," we mean 10V rms into 600Ω at* $V_s = \pm 18V$. Great for active filters or low-signal transducers.

If you don't need two op amps on a single chip, check out our 5534. Same super features as our 5533. And this one's already become an industry standard. For industry-standard BiFETs packaged in plastic check out our LF 355 and LF 356. Whatever you choose, these super low noise performers are just a sampling of Signetics' broad analog circuits line. You'll find a part to meet any spec—including speed, with our very fast NE5539 op amp. Find out how to get the noise out. Contact your nearby Signetics sales office or authorized distributor. Or write: *Signetics Corp., 811 E. Arques Ave., P.O. Box 409, Sunnyvale, CA 94086. Telephone 408/739-7700.*

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Part Number	Key Specifications
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NE5533 (dual)	**Low Noise:** $4.5\text{nV}/\sqrt{\text{Hz}}$ (max.); 200kHz power BW @13V/μsec slew.
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ED621

NEW for HP Desk Top Computer Users

If you use HP 9800* series Desk Top Computers you should get to know Infotek. We are now in our fifth year of producing powerful enhancements for the HP 9825, 9830 and 9831.

Infotek now introduces add-in memory and floppy disk systems for the HP 9835 and 9845.

As always, Infotek's add-in memory is fully compatible to your HP Desk Top system. The only differences are **immediate availability, lower cost and a one year warranty**.

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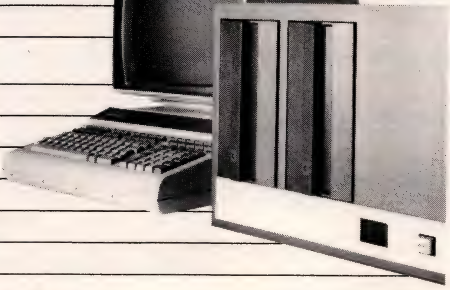
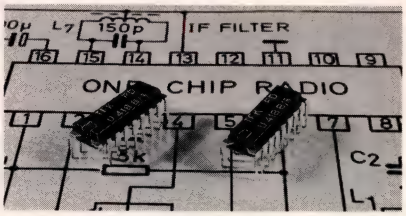


CIRCLE 68

One-chip radios bring in AM/FM



Two "radio-on-a-chip" ICs, U417B and U418B, feature AM and FM i-f circuits and demodulators, an AM oscillator, an rf stage, a mixer, an audio amplifier and a voltage regulating circuit. The circuits are intended for compact, low and medium-class AM/FM radio receivers and communication/navigation equipment. Power consumption is typically 450 mW from a wide 3 to 15-V supply range. Audio output is 700 mW for the U417B and 1 W for the U418B. U417B comes in a 16-pin DIP while the U418B is housed in an 18-pin DIP.

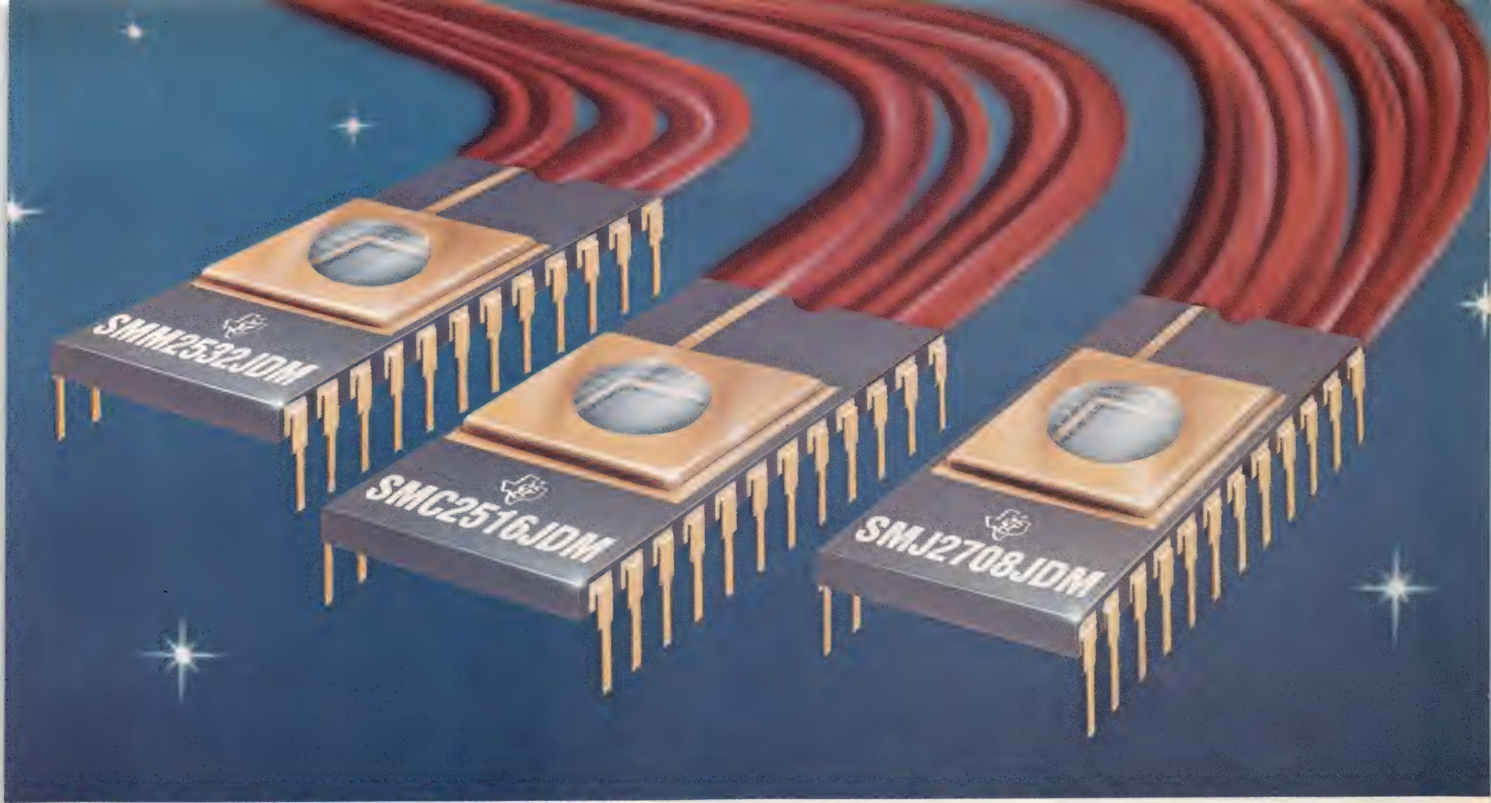
AEG-Telefunken, Rt. 22—Orr Dr., Somerville, NJ 08876. (201) 722-9800. **CIRCLE 322**

CMOS circuit assigns time slots

A variable time-slot assignment and line circuit control device, MC14418, simplifies hardware design of central-office and private branch exchange digital switching. The device operates at rates to 2.56 MHz at 0 to 64 time slots per frame. Control functions offered include ring enable, ring trip, power down and tone and data control. Active power requirement is 60 mW maximum, decreasing to approximately 1 mW in power-down. Supply requirement is 5 to 16 V.

Motorola Semiconductor Products, 3501 Ed Bluestein Blvd., Austin, TX 78710. Bob Karasch (512) 928-6237. $7.50 (plastic); $8.80 (ceramic) (100 qty).

CIRCLE 323



The first family of -55 to +125° C military EPROMS is available now. From Texas Instruments.

Now, for the first time, systems designers can select from a full complement of military grade memories operational over the full temperature range, −55 to +125°C.

And, you can make that selection from TI's growing full temperature EPROM Family.

Processing and speed options

The military versions of TI's EPROM Family are available in three processing levels:

- SMM: Military processed
- SMC: 883B — Vendor equivalent
- SMJ: 883B

You can specify either the 2708 or 2516 in both 350 and 450-ns versions. The 2508, fastest 8K EPROM available anywhere, clocks in at 250 and 300 ns.

Low-power 8Ks, 16Ks and 32Ks

A 446-mW 2508 and a 525-mW 2516, standard 2708s and 2532s, along with their low-power versions, 27L08 and 25L32, dissipating 580 mW and 500 mW, respectively, offer the designer more flexibility than ever before.

Temperature options

For systems that don't require full temperature operation, check and choose from these cost-effective military processed options:

SUFFIX	OPERATION
L	0 to 70°C
C	−20 to +85°C
R	−55 to +85°C
S	−55 to +100°C
M	−55 to +125°C

Family compatibility and availability

All TI Military EPROMs are pin-compatible in rugged 24-pin dual-in-line ceramic packages.

Upgrading is simple because the family concept is designed in. Like all TI EPROMs, the military versions are also erasable, reprogrammable and upgradable. At any time.

All offer reliable, state-of-the-art performance and most are available off-the-shelf at your nearest authorized TI distributor.

Military systems designers can continue to depend on TI's firm commitment to innovative military memory products.

For performance. For reliability. For compatibility. For upgradability. For availability. For economy. And for speed.

For more information about TI's military EPROM Family, contact your distributor or TI local field sales office. Be sure to ask about TI's military versions of static and dynamic RAMs. For details, write to Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265.

Fifty Years of Innovation

TI's Growing Military EPROM Family

DEVICE	TEMP RANGE +	PROCESSING LEVEL*	OPERATING MAX POWER STD	LOW POWER	ACCESS TIME ns	ORGANIZATION
2532	L,C,R,S,M	SMM, SMC, SMJ, 883B	840 mW	500 mW	450	4K x 8
2516	L,C,R,S,M	SMM, SMC, SMJ, 883B	525 mW		350, 450	2K x 8
2508	L,C,R,S,M	SMM, SMC, SMJ, 883B	446 mW		250, 300	1K x 8
2708	L,C,R,S,M	SMM, SMC, SMJ, 883B	800 mW	580mW	350, 450	1K x 8

*SEE PROCESSING OPTIONS

TEXAS INSTRUMENTS
INCORPORATED

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82914A

CIRCLE 69

From the motion picture "The Graduate," ©1967 Avco-Embassy Pictures Corp.

"I JUST WANT TO SAY ONE WORD TO YOU..."

"HITACHICMOSPLASTICS!"

INTRODUCING HITACHI CMOS PLASTIC TECHNOLOGY

Now, more than ever before, the world depends on electronic technological advancement to reduce our energy problems. And, we've responded. Through Hitachi CMOS technology.

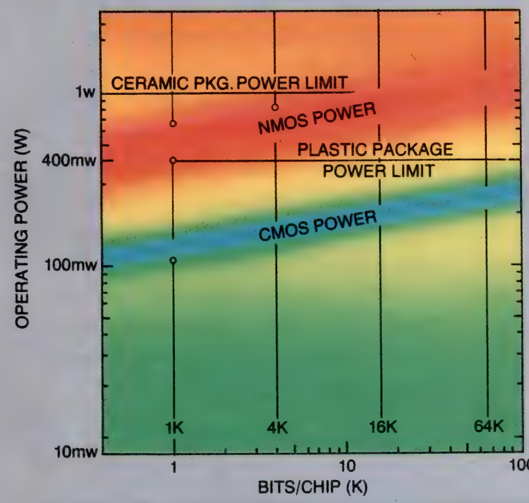
"HI-CMOS"

A technology so unique, it's enabled us to combine the low power of CMOS and the high speeds of HMOS with cost-effective NMOS densities.

With the low power of Hitachi CMOS we can now offer high-speed static RAMs in plastic with densities up to 16K.

CMOS PLASTIC VS. NMOS POWER LIMITS

Hitachi CMOS plastic technology allows plastic packaging of high-speed static RAMs to densities of 64K and beyond, whereas NMOS reaches the limit at 16K.



POWER IN HIGH-SPEED STATIC RAMs

This advanced CMOS plastic technology means you'll need only 200mw to operate our 16K devices compared to the 700mw operating power required by standard 16K NMOS cerdip RAMs.

MORE REASONS TO CHANGE TO CMOS PLASTIC

Pin-for-pin compatibility. Comparable high speeds. Radically lower-power dissipation. Lower operating temperatures. Reduced need for high-current power supplies. Prices competitive with NMOS cerdip RAMs.

The list goes on, but only you can make the comparison for use in your application.

Part No.	Organization	Speed	Operating Power	Availability
6147	4K x 1	55/70	75mw	Now
6148	1K x 4	55/70	150mw	Samples
6116	2K x 8	120/150/200	200mw	Samples
4334	1K x 4	300/450	20mw	Now
4315	4K x 1	350/450	20mw	Now

The IR100 award winning HM6147 CMOS memory exemplifies this line of state-of-the-art products. A unique combination of high-speed NMOS memory cells and low-power CMOS peripheral circuits yield fast (55ns) access times with the low-power dissipation (75mw) characteristic of CMOS technology.

Compare our plastic packaged HM6147, 4K x 1 CMOS RAM with your present 2147 device. You'll find ours offers unduplicated power advantages plus comparable speeds.

Then compare our HM6148, 1K x 4 with any 2148. Our 55ns access time meets that of your 4K high-speed NMOS static, but only Hitachi adds lower-power characteristics: including 150mw operation and only 5μW during complete standby.

And, our 16K HM6116, 2K x 8 has an address access time of 120ns with low-power dissipation during operation of 200mw, just 20μW during complete standby.

SAY GOODBYE TO HIGH POWER DISSIPATION PROBLEMS

Just say "HITACHICMOSPLASTICS" to your Hitachi representative or distributor for data sheets, samples and prices. He'll make delivery, reduced power dissipation and lower cost a sure thing.

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Hitachi, Ltd. Tokyo, Japan

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CIRCLE 70

Now...
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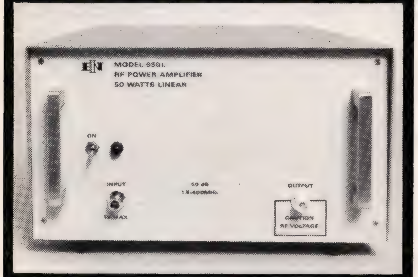
RF power
amplifier you
may ever need.

The new ENI 550L
delivers 50W, 1.5-400 MHz.



This single unit is so incredibly versatile it can replace several you may be using now. And you may never need another. It's an extremely broadband high power, solid state, Class A linear amplifier. It's rated at 50W from 1.5-400 MHz. But it can provide 100 Watts from 1.5-220 MHz. All you need with the 550L is any standard signal or sweep generator and you've got the ultimate in linear power for such applications as RFI/EMI testing, NMR, RF Transmission, ultrasonics and more.

And, like all ENI power amplifiers, the 550L features unconditional stability, instantaneous failsafe provisions, and absolute protection from overloads and transients.

The 550L represents the pinnacle in RF power versatility. There's nothing like it commercially available anywhere! And it may be the only RF power amplifier you ever need.

For more information, a demonstration, or a full line catalog, please contact us at ENI, 3000 Winton Road South, Rochester, NY 14623. Call 716/473-6900, or telex 97-8283 ENI ROC.

ENI

The advanced design line of power amplifiers

CIRCLE 71

CMOS octal circuits more than equal bipolar

Iso CMOS octal decoders and demultiplexers match bipolar 74LS circuits in drive and propagation delays but dissipate one-thousandth of the power. The Mitel 137/8/9 circuits with noninverted outputs and 237/8/9 circuits with inverted outputs are pin and performance-compatible to the popular 7DLS family of interface buffers, latches and decoders. With a load of 15 pF and 2 kΩ, propagation delays are 15 ns typically for an address input high-to-low transition and 22 ns typically for an input low-to-high.

The 137/237 one-of-eight decoders have latches on the three address inputs to permit glitchless operation where needed. The 138/238s are nonlatched one-of-eight decoders, and the 139/239s are dual one-of-four decoders. Supply current is just 0.1 mA with the outputs open, although each output can handle 24 mA.

The Mitel family of Iso CMOS products includes octal latches and buffers. Transparent latches are the 373 (533 inverted) and 573 (563 inverted); flip-flops are the 374 (534 inverted) and 574 (564 inverted). Octal buffers are the 1240/540 and 241/541 noninverting and inverting units and the 1244 noninverting unit.

All latches offer propagation delays of 12 ns typically (with a load of 45 pF and 667 Ω), and operate at frequencies up to 20 MHz. With the outputs disabled, the supply current is typically 0.1 mA. All buffers have delays of 9 ns for a low-to-high input change, and 12 ns for a high-to-low change (with a 45-pF and 667-Ω load). Supply current is also just 0.1 mA with the outputs disabled. Each output can drive 24 mA so long as the package power rating is not exceeded.

All these members of the MDF45C family operate over a power supply range of 3 to 7 V, although their performance is guaranteed at a 5-V level. Initial samples are now available and full production quantities are expected in the third quarter of 1980. In 100-quantity lots, the MD745C 137/8/9 and 237/8/9 decoders are \$3.13; the 240/1/4 and 540/1 buffers are \$3.38; and the 373/4, 533/4, 563/4 and 573/4 flip-flops are \$4.38. Also available is an older circuit, the MD74C245, which costs \$4.47 and will soon be upgraded to the specifications of the MD745C family.

Mitel Semiconductor, P.O. Box 13089, Kanata, Ottawa, Ontario, Canada K7K1X3. Peter Richmond (613) 592-7122.

CIRCLE 305

EEPROM retains 2-k × 8-bit data

An electrically-erasable PROM, HN48016, stores over 16 kbits. Organization is 2048 × 8-bits. Maximum access time is only 350 ns; programming time, 10 ms/byte; erasing time, 1 s (all bit erase). I/O levels are TTL compatible. The maximum number of cycles is 1000, while data retention is longer than 10 years at 85 C. Uses include storage of control programs in computers and preservation of data in a power failure.

Hitachi America, 707 W. Algonquin Rd., Arlington Heights, IL 60005. (312) 593-7660.

CIRCLE 411

Digital accuracy in an analog recorder.

Gould's newest digital writing systems provide superior accuracy in full-scale overlapping traces without overshoot.
Gould's fixed linear array writing systems give you trace precision and reliability unmatched by conventional writing methods. Both the ES 1000 and the TA 600 provide faster rise time, higher resolution, full-scale overlapping display of all channels at user's discretion, excellent square wave and peak capture, simultaneous grid generation, and complete annotation of necessary information from internal and external sources.

The ES 1000 electrostatic analog recorder.

- Records frequencies up to 15 kHz on as many as 16 channels through versatile plug-in signal conditioners.
- Records transient signals lasting more than 40 μs at full value.
- Chart speeds from 5 to 250 mm/s.
- Produces clear, high contrast permanent records on 11-inch wide roll or Z-fold electrostatic paper which is 1/4 the cost of photo sensitive paper.

The TA 600 thermal array analog recorder.

- Records up to 320 Hz on as many as 32 channels through versatile plug-in signal conditioners.
- Displays at full value any pulse lasting over 625 μs.
- Produces permanent records on 6-inch wide roll or Z-fold thermal paper.
- Chart speeds from 50 mm/s to 1 mm/h.
- Optional microprocessor gives the TA 600 the versatility for the most advanced recording applications.

For more information, write Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, Ohio 44114.

For brochures call toll-free: (800) 331-1000.
In Oklahoma, call collect: (918) 664-8300.

In Europe, contact Gould Instruments S.A.F., 57 rue St. Sauveur, 91160 Ballainvilliers, France.

GOULD
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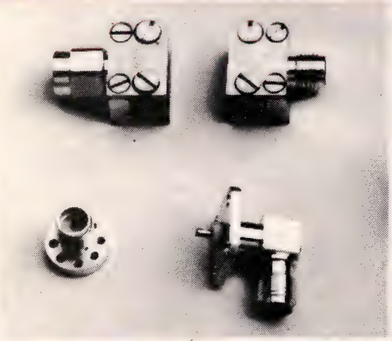
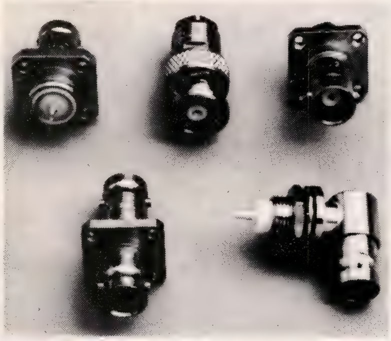
CIRCLE 72

SMA
SMB·SMC
& BNC
Coaxial Connectors



SMA,SMB, SMC Series SOCAPEX manufactures an extensive line of Miniature Coaxial Connectors suitable for cable, panel, printed circuit and chip applications in high frequency microwave components and systems.

Our SMA, SMB, and SMC Connectors are manufactured and tested in accordance with the requirements of MIL-C-39012 and several configurations have been qualified to these specifications by independent test laboratories.



BNC Series SOCAPEX manufactures a broad line of high quality BNC Connectors (50 and 75 ohm) for use in low frequency applications.

A variety of MIL-Spec/UG classifications are available for use with standard coaxial cables from .080 to .440 inch O.D. Crimp and captive-contact versions are included.

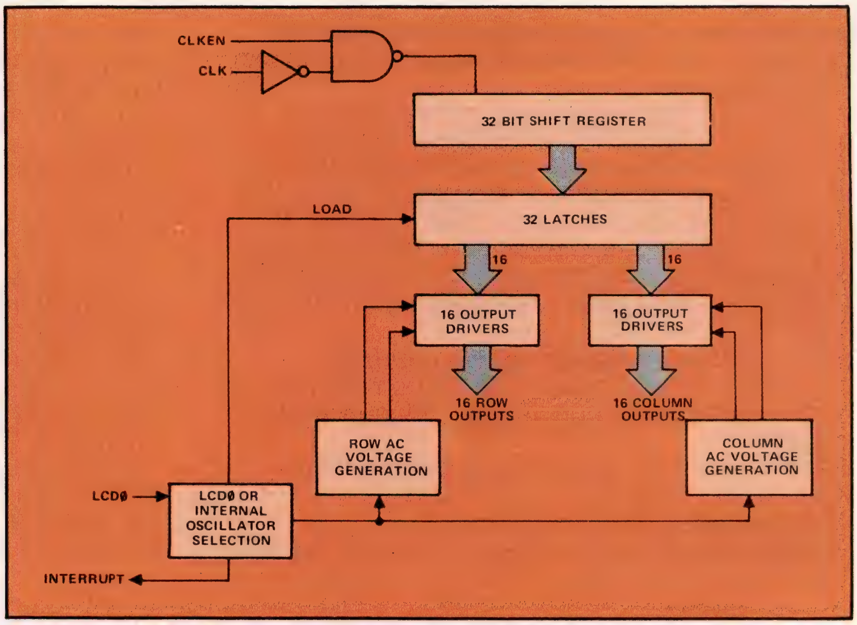
Connectors with isolated (floating) ground leads are available for applications where system and chassis grounds must be independent.

Call today for price, delivery or sample!

SOCAPEX
6660 Variel Ave., Canoga Park, CA, 91303
(213) 887-0750

THOMSON-CSF
CIRCLE 74

Low-power LCD drivers handle dot displays



The HLCD 0548 liquid-crystal-display driver is configured for driving 16 rows and 16 columns; units can be cascaded for driving larger displays.

Most available liquid-crystal-display drivers are intended for alphanumeric displays. Hughes Aircraft's latest, on the other hand, are much more ambitious: The HLCD0540 can handle 32-point row or column displays, while the HLCD0548 can handle a 16 × 16 dot matrix. Both are fabricated in CMOS to keep the power requirement low. Supply voltages range from 3 to 15 V.

There are plenty of other similarities. Both drivers come in 40-pin packages. Both have serial data inputs. And both have on-chip oscillators that can operate at clock rates of up to 1.5 MHz to provide flicker-free displays.

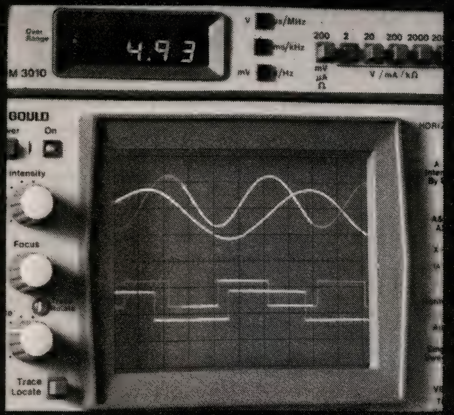
What's more, both the 0540 and 0548 can be cascaded to make larger displays—in fact, two 0540s can be combined to provide a 32-row × 32-column display simply by selecting the drive functions for each driver through its ROW/COL select pin. And, thanks to a simple serial interface and interrupt control pin, the drivers can easily be interfaced to microprocessor systems. All inputs, by the way, are CMOS, nMOS and TTL-compatible. And operating current for either driver is at most 500 μa at a V_{DD} of 15 V.

Driver-output voltage levels for the row outputs are V_{DD} for an output high, close to 0 V for an output low, and about half of V_{DD} when the output is unselected. For the column lines, the swings are about 0.68 V_{DD} for an output high and 0.32 V_{DD} for an output low. Data-in setup time (data change to clock fall) is a minimum of 300 ns, data hold time (clock fall to data change) is 100 ns, and the LCD0 to interrupt-out delay (clock fall to interrupt-out rise) is 300 ns.

Hughes Aircraft, Solid State Products Div., 500 Superior Ave., Newport Beach, CA 92662. Bill Eckess (714) 759-2943.

CIRCLE 302

Now—Gould quality in a 100 MHz oscilloscope.

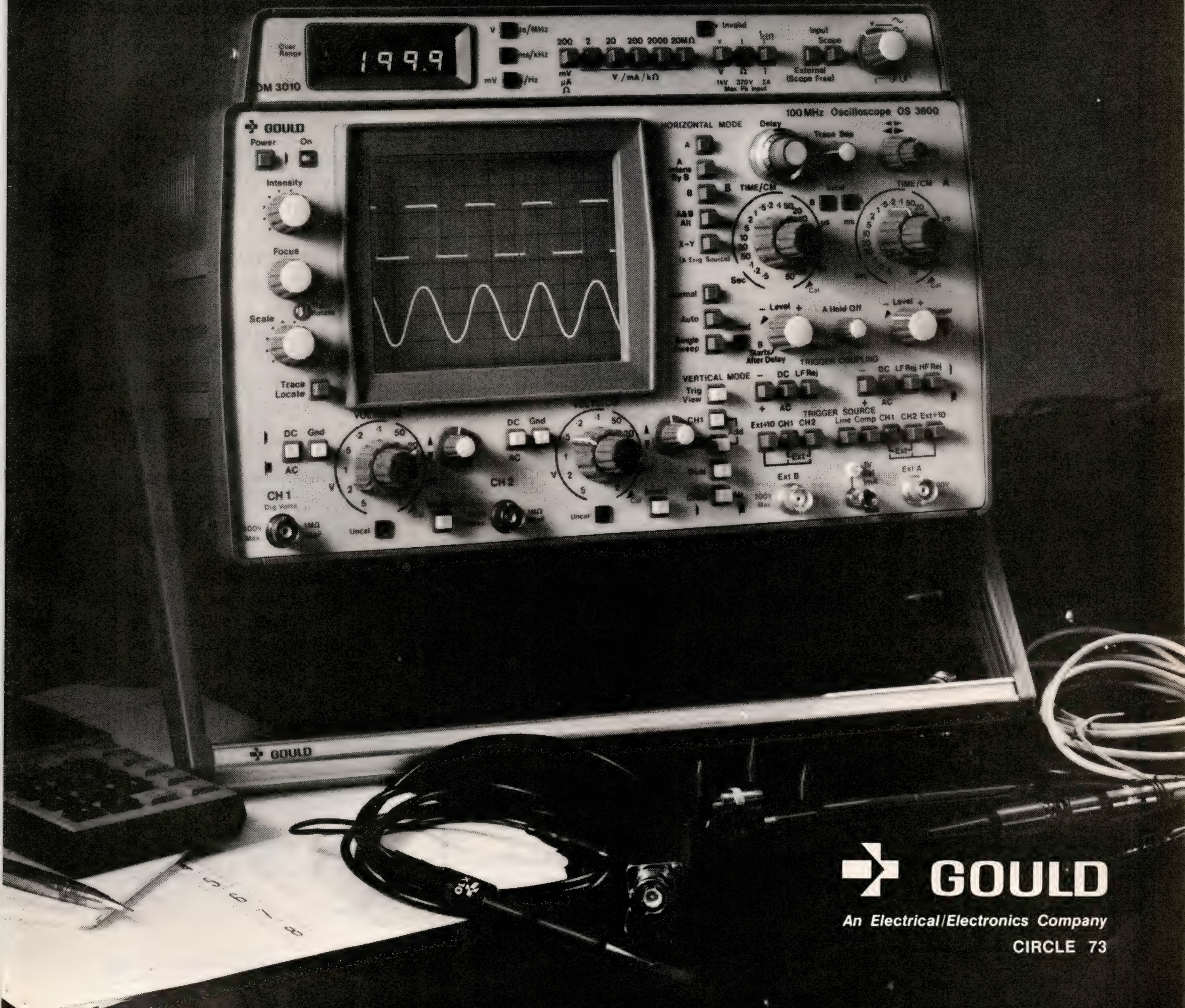


No scope on the market has more of the features you need than the new Gould OS3600 with optional DMM. You can use the OS3600 on any electrical/electronic circuit from digital to conventional with exceptional results.

With vertical sensitivity of 2mV/cm up to 85 MHz, the OS3600 can examine extremely low level signals. The 4-trace capability allows comparison of original and delayed sweeps.

The bright, flicker-free CRT displays even narrow pulses with low repetition rates. The optional 3½ digit DMM is available as a factory fit or retrofit. Plus, the OS3600 is backed by a worldwide service network and a unique 2-year warranty that covers all parts and labor (exclusive of fuses, calibration, or minor maintenance).

Write Gould Inc., Instruments Division, 3631 Perkins Avenue, Cleveland, OH 44114. Call toll free 800-331-1000 (in Oklahoma, call collect 918-664-8300).



GOULD

An Electrical/Electronics Company

CIRCLE 73

Digital lock chip restricts area access

A digital lock system, LS7225, guards machines, areas and burglar alarms against unauthorized access. The 14-pin DIP offers 5040 four-digit combinations and includes a special tamper output. The chip detects the proper sequential closing of four keys to toggle the lock-control output. Improper sequencing or activation of a "dummy" input key resets the chip and activates the tamper output. The device operates from 5 to 18 V dc and typically draws only 25 μA in standby.

LSI Computer Systems, 1235 Walt Whitman Rd., Melville, NY 11747. (516) 271-0400. $1.25 (1000 qty); stock. **CIRCLE 407**

4-k CMOS RAM takes less power

A 4-k CMOS static RAM, the MSM 5114, directly replaces industry-standard 2114L parts yet consumes less power. Use of the new RAM reduces system power supply requirements. The device is organized as 1024 × 4 bits and provides TTL compatible I/O. A single 5-V supply requirement simplifies system designing.

OKI, 1333 Lawrence Expwy., Suite 401, Santa Clara, CA 95051. (408) 984-4842. $18.10 & $20.15 (100 qty); stock. **CIRCLE 408**

32-k static ROM subs for 2732/2332

A 32-k static ROM, the RO-3-9333 substitutes for Intel's 2732 and 2332, Synertek's SY2333 and AMD's AM9233. The device is organized as 4096 × 8-bits and features an access time of 450 ns maximum. RO-3-9333 is fully static and requires no clocks. All inputs and outputs are TTL compatible.

General Instrument Microelectronics, 600 W. John St., Hicksville, NY 11802. (516) 733-3120. $11.87 (1000 qty); 4 to 6 wks. **CIRCLE 409**

6-MHz Z80 upgrades slower μP circuits

A faster version of the popular Z80 microprocessor, the Z80B, upgrades systems based on the chip's slower predecessors, the Z80 and Z80A. The new chip is completely pin and software compatible with the earlier devices yet runs at a 6-MHz clock rate, compared to the Z80A's 4-MHz rate and the Z80's 2.5-MHz speed.

Zilog, 10340 Bubb Rd., Cupertino, CA 95014. (408) 446-4666. $20.00 (plastic); $3.85 (cerdip) (10 qty). **CIRCLE 410**

We ship your shape within 6 weeks. Or 3 days.

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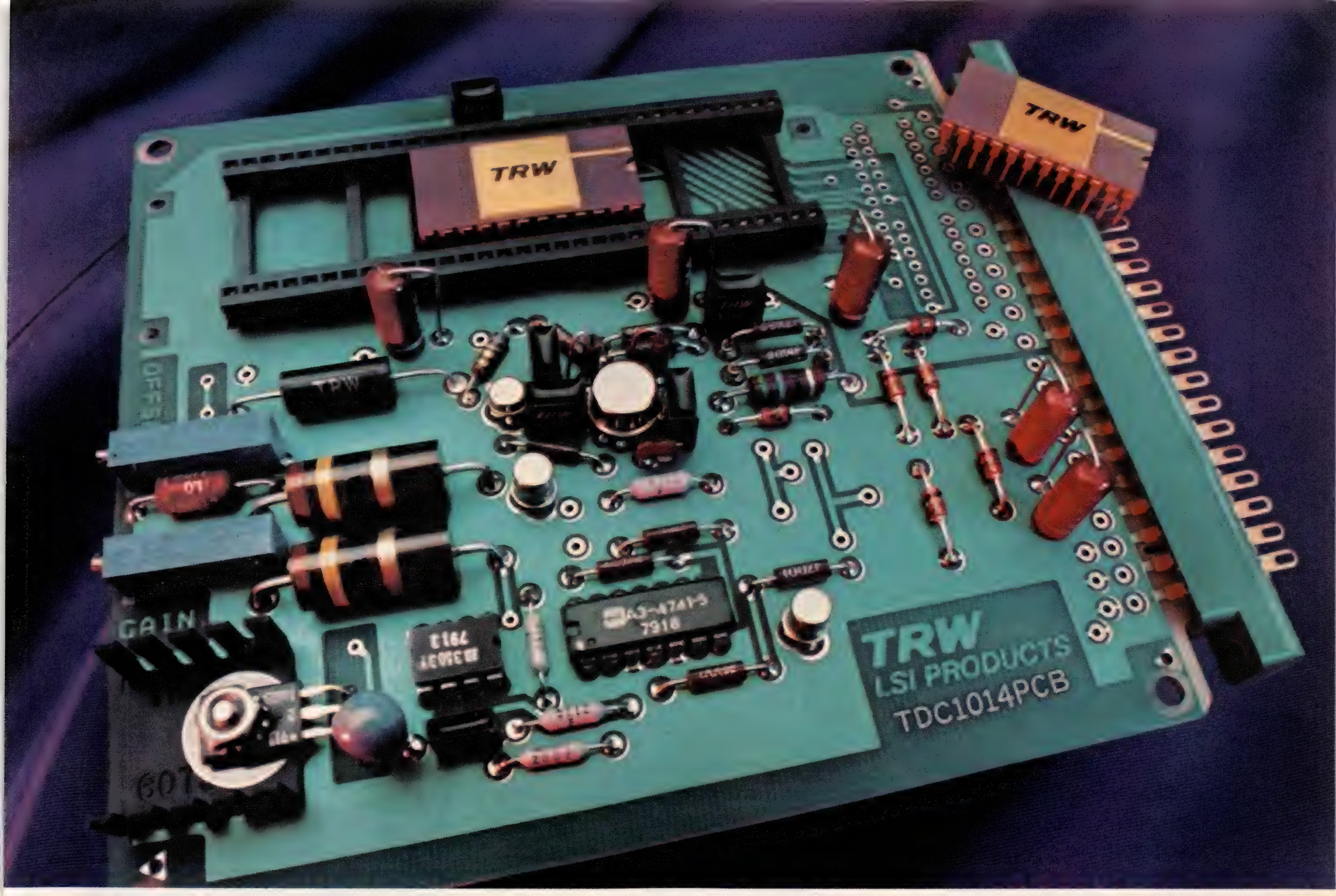
CIRCLE 75



This monolithic 6-bit, 33 nsec A/D converter has everything

(And a test board to prove it.)

Order our monolithic 6-bit 33 nsec A/D converter on its own fully assembled evaluation board (4½" x 5½", complete with 44 pin edge connector). Using +5 and ±15V power supplies, the board accepts and digitizes a 1V peak to peak signal from a 75Ω source at sample rates from DC to 30 megasamples per second.

Use it for performance evaluation of the converter. For system prototyping. As a test fixture. Price for **TDC1014PCB** 6-bit converter and board: **just $218** (only $168 in 100's).

Or if you prefer, order just the 6-bit converter **(TDC1014J)** by itself. Competitively priced at **just $93** (in 100's), the TDC1014J is a fully parallel (flash) A/D converter.

If you're working in data conversion with **video bandwidths** take a look at these features:

With or without the evaluation board, these 6-bit video speed converters are **in stock** at your local Hamilton/Avnet distributor.

- 6-bit resolution
- ±1/4 LSB linearity
- 30 megasamples per second (33 nsec)
- **no sample-and-hold** circuit required
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ED-6

TRW LSI Products
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Company ______________________

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Address ______________________

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State ______________ Zip ________

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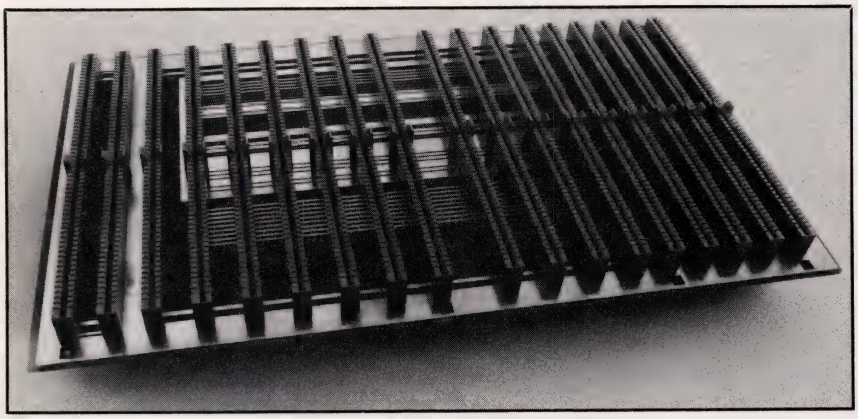
TRW keeps you ahead in digital signal processing

CIRCLE 76

Standard parts customize a backplane



Backplane assemblies called Contact-Serts are designed easily and quickly to a customer's dimensional and layout specifications. The assemblies, developed by Hybricon, are made from standard volume-produced parts, such as contacts on reels and shell sections for connector housings. Hybricon will also do wire wrapping to customer specifications when supplied with a routing list.

Contacts for the Contact-Sert assemblies can be press-fitted into two-sided or multilayer PC boards with plated-through holes. Contacts can be made with selective gold plating and gold or tin-plated tails. Board and contacts thus become rugged, integral assemblies that can accommodate multiple power and ground planes with high-current capability.

Standard contact plating is a 0.1-in. stripe of gold, 0.03 mils thick, on top of 0.05 mils of nickel on the contact area. On the rest of the contact body and tail is a gold flash, 0.005 mils thick (0.003 mils minimum) over 0.05 mils of nickel. To cut costs, the body and tail of the pin outside the contact area can be plated with 0.2 mils of tin over copper flash.

Hybricon Corp., 410 Great Rd., (Rt. 119), Littleton, MA 01460. C. Michael Hayward (617) 486-3174.

CIRCLE 301

Dicer slices substrates with precision

A substrate dicer, Model 110, replaces silicon saws for cutting extremely hard substrate materials. Used with a resinoid diamond blade, Model 110 cuts through ceramic, quartz, sapphire, lithium niobate, gallium arsenide, ferrite, garnet, ruby and barium titanate. Kerfs as narrow as 0.0015 in. can be cut without damage to substrates. A full-color optical display screen allows the operator to view cutting surfaces without the use of a microscope.

UTI, 325 N. Mathilda Ave., Sunnyvale, CA 94086. (408) 738-3301. $23,750.

CIRCLE 405

HAYDEN TAPES
ARE NOT
SOMEWHERE
OVER THE
RAINBOW...

SLOW LIST/STOP LIST (Gilder) Start, stop, and control the speed of your program with Apple II's game paddles. Control the speed at which the disk catalog appears and terminate CATALOG operation in the middle. The program can be enabled and disabled under software control. **#03904, Apple II, $10.95**

REVIVE (Gilder) When a program is accidentally erased, REVIVE searches through memory and finds the information that enables it to restore the pointers that have been changed. Can be loaded at any time, even after you have accidentally erased the program. **#03604, Apple II, $19.95.**

SONGS IN THE KEY OF APPLE (Lopatin). Allows you to see and hear your favorite tunes, pre-programmed tunes, or music you create (up to 200 notes, including rests per musical piece). Multi-color graphics accompany all music. **#03304, Apple II, $10.95.**

APPLESOFT UTILITY PROGRAMS (Gilder) Contains 9 subroutines, among them 3 different statement formatters: REM, PRINT, and Pokewriter. Other subroutines included are: calculating the decimal address of your machine language program, checking for illegal branches and indicating where one exists, joining two or more programs together, etc. **#03504, Apple II, $29.95.**

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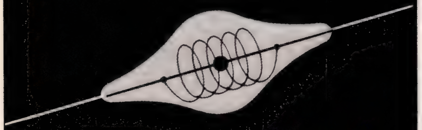
Telephone: 41(22) 34-90-55
Telex: 22647 ITGE CH.

CIRCLE 78

Another example of Gulton electroceramics:



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These bead thermistors are thermally biased to provide...

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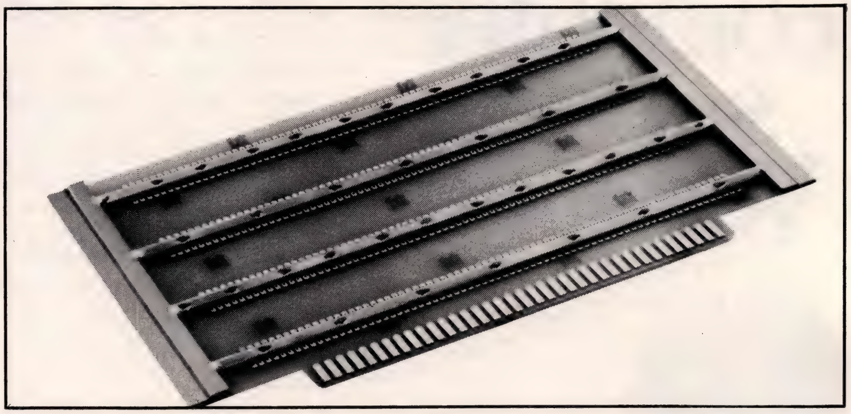
ZIF side guides reduce board stress



Metal bars and side rails on a circuit board conduct heat away from DIPs that straddle the bars. Locked solidly in the ZIF side guides, the side rails dissipate the heat to the card cage.

A line of zero-insertion-force guides for the side of printed-circuit boards keep board stress low during installation. The guides, from IERC, also provide a low-thermal-resistance path between the boards and the chassis in which they are mounted. The guides lock the boards firmly into position; and thanks to ZIF, the boards won't be scored when inserted or withdrawn.

Rotating a cam actuator 90° opens or locks the ZIF guides, which vary in length from 1.5 to 10.5 in. and accommodate 1/16-in.-thick boards. The guides are designed to meet military-environmental specifications, so weight has been kept to just 0.0126 lb per inch of length.

The standard finish is a black anodize, but chemical-film and unplated versions are available for applications needing low electrical impedances to ground. Mounting methods include bolting, rivetting, eyeletting, epoxy bonding and brazing.

To conduct heat from DIP circuits on a board to the side guides, IERC offers conduction bars and side rails—both made of certified, high-thermal-conductivity, solder-plated copper. Standoffs raise the bars 0.020 in. above the board to accommodate the DIPs and stiffener ribs. The bars can be wave-soldered in place with other components. The side rails, up to 12 in. long, engage the ends of the conduction bars at the edges of the circuit board.

International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, CA 91502. Edward M. Byrne (213) 849-2481.

CIRCLE 304

Ion-beam system boasts repeatable accuracy

An ion-beam milling system, MIM-TLA 10, uses a collimated ion beam to etch lines and patterns of less than 1000 Å width in semiconductors, conductors and insulators. The ions are extracted from argon or reactive gas plasmas to provide improved milling rate selectivity. Use of a collimated beam results in anisotropical or unidirectional milling for depth-to-width ratios of up to 10:1.

Technics IMF, 7950 Cluny Ct., Springfield, VA 22153. (703) 569-7200.

CIRCLE 412

COAST-TO-COAST NETWORKS

Solve your resistor network delivery problems by calling your Sprague sales office or stocking distributor.

Sprague supplies the DIP and SIP resistor networks required by customers like you. This table, listing just a few of the more-popular devices, shows how Sprague cross-references with other well-known suppliers.

Description	Allen-Bradley	Beckman	CTS	**SPRAGUE**
Multiple Isolated 14 Pins, 7 Resistors	34B . . . 4 314B . . .	899-3-R . . .	760-3-R . . .	**914C . . . X2SR**
Multiple Isolated 16 Pins, 8 Resistors	36D . . . 4 316B . . .	898-3-R . . .	761-3-R . . .	**916C . . . X2SR**
Pull-up/Pull-down 14 Pins, 13 Resistors	34A . . . 4 314A . . .	899-1-R . . .	760-1-R . . .	**914C . . . X2PE**
Pull-up/Pull-down 16 Pins, 15 Resistors	36C . . . 4 316A . . .	898-1-R . . .	761-1-R . . .	**916C . . . X2PE**
Thevenin Terminator 14 Pins, 24 Resistors	34E 4 314E	899-5-R . . . / . . .	760-5-R . . . / . . .	**914C . . . X2TR**
Thevenin Terminator 16 Pins, 28 Resistors	36E 4 316E	898-5-R . . . / . . .	761-5-R . . . / . . .	**916C . . . X2TR**

4SR-8118R2

For your nearest Sprague sales office, call Jim Fitzgerald at Sprague Electric Co., Tel. 413/664-4411. For your nearest Sprague stocking distributor, call Sprague Products Co. Division, Tel. 413/664-4481.

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

SPRAGUE®
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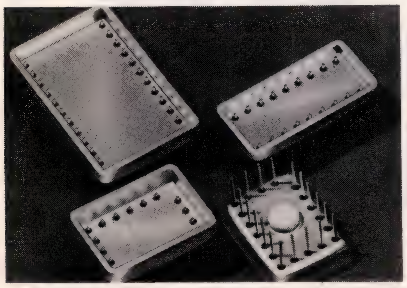
Strong walls protect delicate circuits

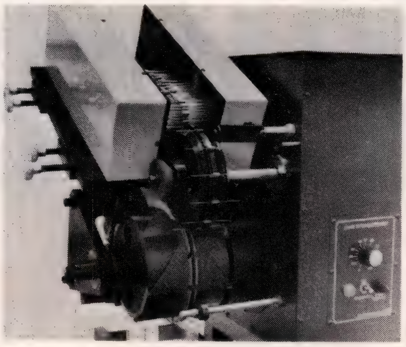


One-piece construction eliminates brazed joints, increasing the strength and reliability of Solid Sidewall microcircuit packages. Basic material is 0.04-in. thick ASTM Alloy 15 (Kovar). The package is gold-plated (per MIL-G-45204) over a nickel plate (per QQN-290). The package is leak-test rated at less than 1×10^{-8} cm^3 of helium per second.

Airpax Microcircuit, Woods Rd., Cambridge, MD 21613. (301) 228-4600.

CIRCLE 324

Lead straightener minimizes jamming



System 1100, a high-speed axial component lead straightener, uses a set of indexing plates to minimize the potential for jamming. The plates travel at twice the speed of the straightening roller, allowing the components to rotate freely. The unit operates at typical production rates of 15,000 to 18,000 units per hour. A continuous cycle drawing of the leads to a straight position assures minimum deformation of the leads. The system operates automatically or under foot-pedal control. Options include a lead trimmer and a hand-feed chute.

GTI, P.O. Box 96, Hadley, PA 16130. (412) 253-3161.

CIRCLE 325

Triple core solder ends flux voids

A triple core wire solder, Flow-solder, uses a constant flux-to-metal ratio to eliminate flux voids. A thin solder wall permits faster melting, flux flow and thorough wetting. The material is available in all standard diameters from 0.125 to 0.02 in. with flux percentages from 0.5 to 4%. Flow-solder is listed under MIL-Spec QQ-S-5571E and comes in 1, 5 and 25-lb spools.

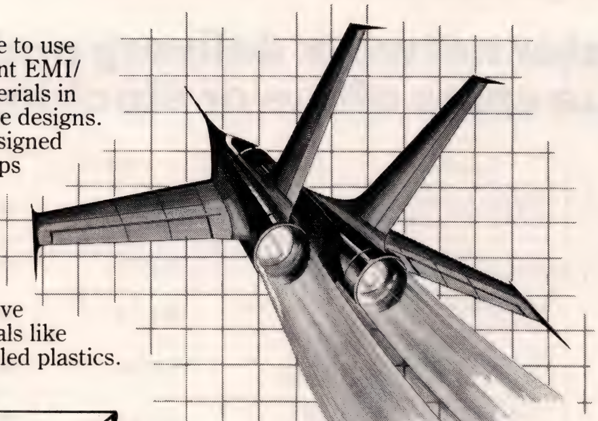
Fry Metals, 50 Sims Ave., Providence, RI 02909. (401) 274-6265.

CIRCLE 326

HOW OUR NEW SHIELDING MATERIALS CAN HELP GET YOUR BEST DESIGN IDEAS OFF THE GROUND.

It makes a lot of sense to use tougher and more resilient EMI/RFI/EMP shielding materials in your aircraft and airframe designs.

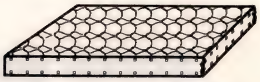
That's why Metex designed new PMP silicone P-Strips and gaskets. They provide both electrical protection and an environmental seal in one package. Even when used with conductive coated composite materials like Kevlar or carbon fiber-filled plastics.



PMP I

PMP I is a calendared material made of a flat piece of silicone with knitted metal throughout only one surface. Available in widths to 20". Thickness ranging from .015" to .092". Designed for special configurations such as P-Sections with a very resilient core.

PMP II



PMP II has wires throughout the material and at both surfaces. Compressing the material provides conductivity throughout. PMP II is an inexpensive, multiple performance, multi-purpose gasket which in many instances is an excellent substitute for silver loaded conductive elastomers.

Because the wires are buried inside the silicone, neither PMP I or PMP II acts as an abrasive shield material. Life span increased 10 times over other equivalent usage gaskets. Product design maintains full integrity of the high tensile strength silicone.

For more information, contact Metex Electronic Shielding Group, a unit of Metex Corporation, 970 New Durham Road, Edison, NJ 08817. (201) 287-0800.

And watch your design ideas really take off.

METEX
ELECTRONIC SHIELDING GROUP

CIRCLE 80

A UNIQUE CHOICE OF DATA ACQUISITION SYSTEMS FOR THE LSI-11/2 AND 11/23. NOW FROM ADAC.

When it comes to data acquisition systems, there is nothing quite like the ADAC Systems 1000 and the new ADAC System 2000.

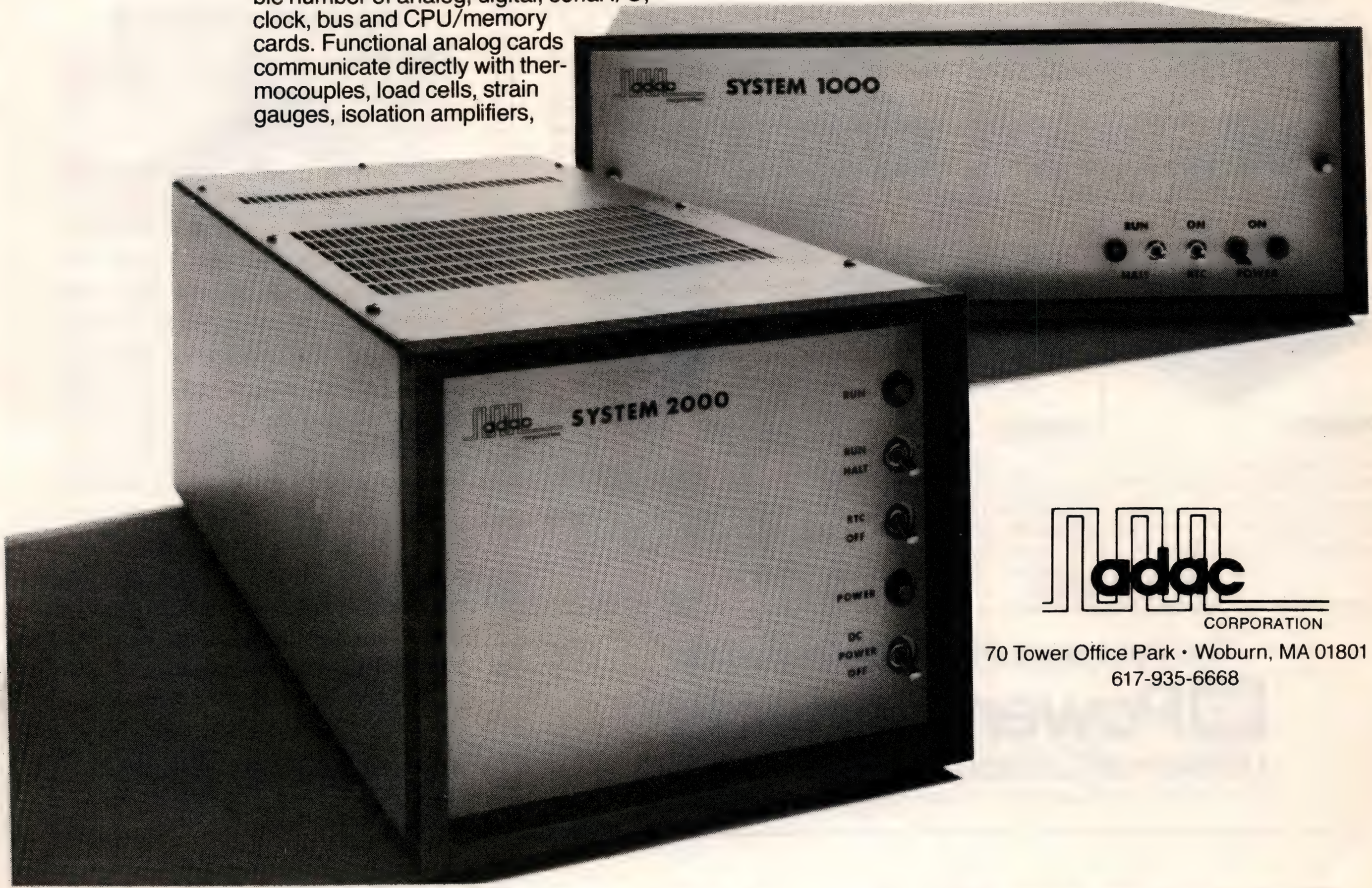
Both systems can operate as low cost peripheral expanders to any UNIBUS computer. When incorporating a DEC LSI-11/2 or 11/23 microcomputer the systems operate as stand alone control systems or as remote intelligent terminals.

The compact ADAC System 2000 is built to hold 13 half quad cards. If you need greater capacity, slave units can be utilized or you can go to the larger System 1000 which accommodates any combination of 11 quad size cards or 22 half quad size cards. Both systems can be bench top or rack mounted and have a universal power supply that can support up to 256 kilobytes of memory.

The real heart of both System 1000 and ADAC System 2000 is their incredible number of analog, digital, serial I/O, clock, bus and CPU/memory cards. Functional analog cards communicate directly with thermocouples, load cells, strain gauges, isolation amplifiers, transmitters and strip chart recorders to name a few. Discrete cards communicate with switch contacts, relays, thumb wheel switches, pumps, motors and other devices. All cards can be purchased as separate items.

A single System 1000 can be supplied with up to 700 high level analog input channels, or 128 analog low level input channels, or 700 digital I/O functions. A typical ADAC System 2000 contains a CPU, 64 kilobytes of memory, floppy disc controller, 16 channel A/D, 4 channel D/A, 32 TTLI/O lines, two serial I/O ports plus room for another six cards of your choice.

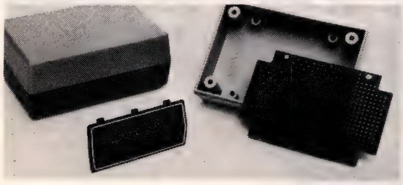
Another nice thing about both systems is their prices. They start at $995 for the ADAC System 2000 and $1550 for the System 1000. So you can choose the combination of price and capability that's just right for your application. Contact ADAC for full details.



adac
CORPORATION
70 Tower Office Park • Woburn, MA 01801
617-935-6668

CIRCLE 81

Modular boxes build prototype enclosures



Unibox, a series of packaging components, allows construction of a wide variety of enclosures to house prototype designs. The boxes are made of tough engineering-grade thermoplastic but can be customized with hand tools. Epoxy-glass Gridboards mount vertically or horizontally within the enclosures. The boards accept IC sockets and other standard-lead configuration parts. Two sizes of transparent red and smoke-gray windows allow use of LED or incandescent readouts or indicators. Opaque panels facilitate mounting of switches, connectors and potentiometers. Nonmarring feet protect tabletops.

Amerex, P.O. Box 2815, Riverside, CA 92516. (714) 686-1414.

CIRCLE 327

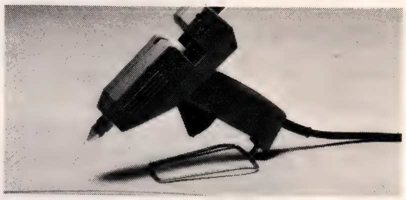
Plastic enclosure houses AIM 65 μC

An ABS plastic enclosure houses the single-board AIM 65 microcomputer. The cabinet comes with mounting hardware, wire and switches. All parts are pre-cut and drilled and can accommodate two additional boards.

Don-El Enterprises, 3261 Michigan Ave., Costa Mesa, CA 92626. (714) 546-7481. $49.95.

CIRCLE 328

Hand gun dispenses hot-melt adhesive



An easy-to-use hand gun, the Polygun AE, dispenses hot-melt adhesives at the touch of its trigger. Since the applicator needs no compressed air, it can be used anywhere a 110-V power source is available. The applicator dispenses adhesives at a rate exceeding 2 lb/h and does not require interim shut-down during periods of nonuse. The applicator uses 12-in. long Jet-melt cartridges which melt on demand. The adhesive wets a bonding surface and hardens without chemical change.

3M Adhesives, Coatings and Sealers, 223-6NE, 3M Center, St. Paul, MN 55144. **CIRCLE 329**

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We ship all popular AC-DC power supplies within three days ARO.

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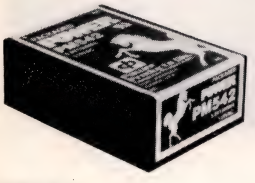
Power Products' exclusive Blue Streak Delivery System ensures quick shipment of prototype (1-3 piece) quantities. So you can power-up a new design sooner.

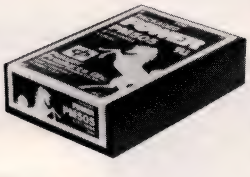
Choose from more than 50 standard supplies, like the popular models shown here. We stock single, dual, and triple output power supplies, featuring all popular outputs from 3.6 to 28 volts. Why wait? We can put the power in your hands in just three days from now!

Call or write for our free catalog before you're pressed for power. Or, if you need it now, order today. And ask for Blue Streak Service.



PM542

5.0V @ 1A.Regulation: ±0.02% Line/±0.04% load. 1.0mV RMS Ripple/Noise. Built-in overvoltage protection. Powers all popular digital logic. $45.00*



PM505

±15V @ 100mA. Regulation: ±0.02% Line/±0.02% load. 0.5mV RMS Ripple/Noise. 50 megohms input isolation. Ideal for powering op-amps and precision instrumentation. $33.00*

PM396

±15V @ 500mA. Regulation: ±0.05% Line/±0.05% load. 1.0mV Ripple/Noise. Chassis-mount model for use with linear IC and discrete analog circuits. $78.00*

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CIRCLE 82

SEALECTRO JUMPJAX*

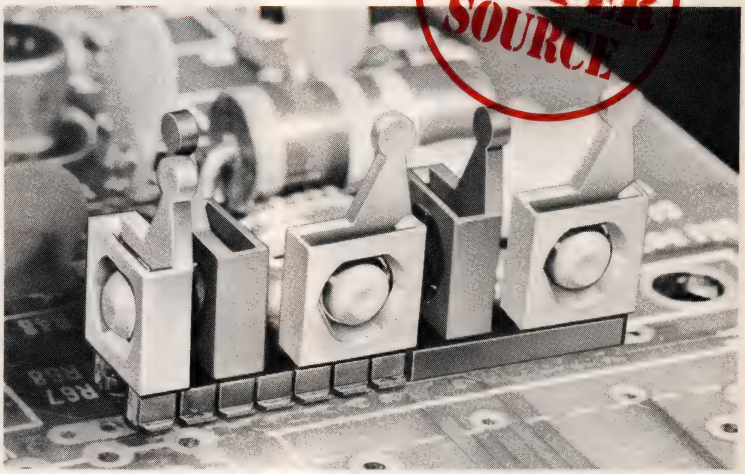
THE JUMPER SOURCE

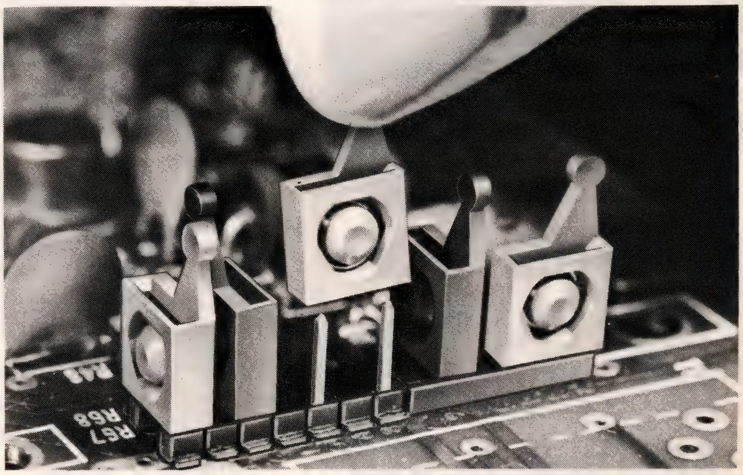
...simple is better!

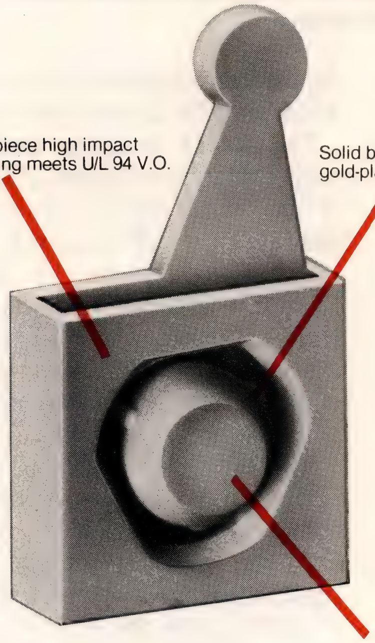
A solid, one-piece contact ring does the trick. This patented, better idea completely eliminates multiple contact assemblies that cause problems. What you see is what you get – a quick glance clearly shows the solid contact between the plug-over pins.

And there's no enclosed housing to trap dirt. The floating ring constantly cleans itself and assures better and longer electrical performance.

Now – all the advantages of a jumper – reliability, no accidental switching, instant readout, elimination of solder contamination – in a simple, better package.



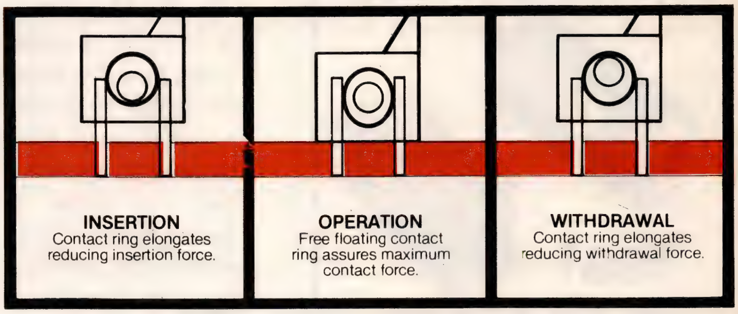




One-piece high impact molding meets U/L 94 V.O.

Solid beryllium copper gold-plated contact ring.

Hub design assures free-float for maximum contact action.



INSERTION
Contact ring elongates reducing insertion force.

OPERATION
Free floating contact ring assures maximum contact force.

WITHDRAWAL
Contact ring elongates reducing withdrawal force.

*Patented

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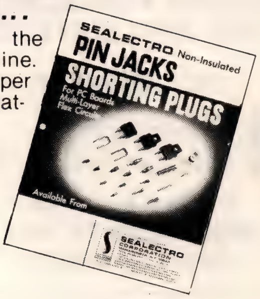
Get full details on the Sealectro jumper line. Jumper plugs, jumper jacks for various pattern spacings...



SEALECTRO Non-Insulated
PIN JACKS
SHORTING PLUGS
For PC Boards
Multi-Layers
Flex Circuits
Available From
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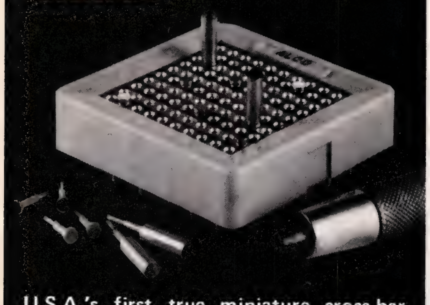
CIRCLE 83

ALCOSWITCH®
pin programming matrix



U.S.A.'s first true miniature cross-bar switch with provisions for 100 program selections on a 10 x 10 matrix. Designed for PC board mounting in standard 0.1" grid centers. Contains all gold plated contact surfaces for dependable logic and signal level circuit connections. Provides a variety of programming, encoding and signal routing applications. AMX-1010 is available for immediate delivery. One to 24 lot price is $18.95 including ten gold plated shorting pins. Diode pins optionally available at $1.25 each. Use singly, in multiples or we will customize to meet your needs. For ordering and additional information, call (617) 685-4371.

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CIRCLE 84

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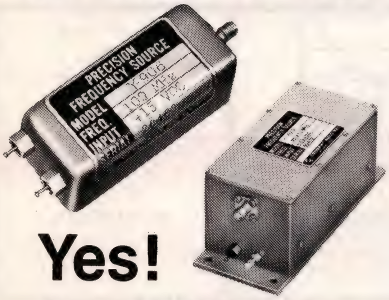

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WE CAN HELP YOU WITH STATE-OF-THE-ART DESIGNS FOR ALMOST ANY APPLICATION!

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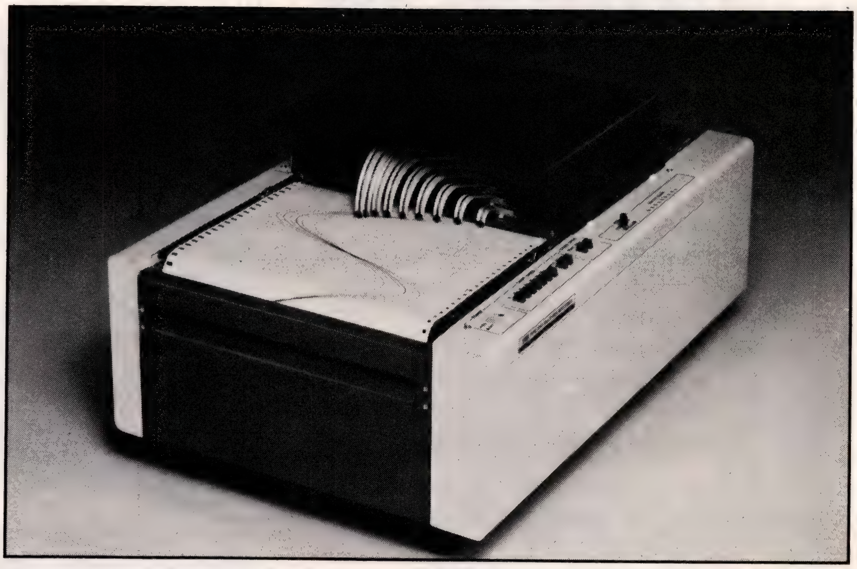
CIRCLE 85

9-channel chart recorder compensates for pen offsets



The mechanical offsets that allow the nine pens of the Model 3063 chart recorder to cross over each other do not cause any errors in the trace alignment thanks to a compensating digital delay line in each channel.

A nine-pen benchtop multichannel chart recorder conquers the two drawbacks common to most other chart recorders: They either restrict each channel to a fraction of the width of the chart paper or they introduce offset errors to allow all of their pens to swing across the full chart width.

In the Model 3063 from Yokogawa Corp. of America, each pen is free to move across the full 250-mm width of the chart paper. But the mechanical offset that allows the pens to cross over each other does not cause errors on the plotted record, because each channel contains a digital "delay line" that compensates for the fixed pen offsets.

The delay line is actually an analog-to-digital converter followed by a read/write memory and then a digital-to-analog converter. The input signal for each channel is digitized, stored for a period of time determined by the chart speed and the mechanical offset of that channel's pen, and finally converted back to analog form and fed to the pen motor.

The motor positions the pen with a maximum error of 0.25% of the chart width within less than a third of a second. The instrument offers 13 input ranges, with sensitivities ranging from 0.5 mV/cm to 5.0 V/cm in a 5-1-2.5 sequence. Chart speeds of 2, 3, 6, 10, 20, 30 and 60 cm/min. and cm/hr are provided.

The 3063 has excellent noise performance. It has a floating, guarded and shielded input. Common-mode rejection is more than 140 dB at both the power-line frequency and dc.

The nine-pen chart recorder sells for $9600. A six-pen version is priced at $7200. These prices are about $2000 more than the prices of the nine and six-pen versions of the Model 3061—a similar recorder that does not provide compensation for pen offset.

Yokogawa Corp. of America, 5 Westchester Plaza, Elmsford, NY 10523. Jack Stegenga (914) 592-6767. **CIRCLE 321**

DIRECTORY BLUES?

Chase them with GOLD BOOK. Some directories promise more than they deliver. You don't find the products you're seeking. You can't locate the manufacturer's address you need. Distributor directories have been eliminated. But check ELECTRONIC DESIGN's GOLD BOOK. Here you'll find the World's Most Complete Electronics Directory. Every effort has been made by the GOLD BOOK editorial staff to publish a listing on every known electronic component, sub-system, and system — and their manufacturers. Over 10,000 US and non-US manufacturers are listed, many with complete sales outlet listings (sales offices, reps and distributors). Two distributor directories (one alpha, one geo) and a trade name directory complete the editorial file. Specs on thousands of products provided by hundreds of manufacturers complement the editorial listings. Every time you need a directory — reach for GOLD BOOK. It's a sure cure for the blues.

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Ground Fault Interrupter Cores, for instance.

High sensitivity in a ground fault interrupter (GFI) is essential in eliminating electrical shock hazards. Magnetics' sensing and neutral detector cores are available in a wide variety of sizes and types to fill almost any GFI circuit requirement.

For highest sensitivity at 40 gauss and 60 Hz, Magnetics' own Permalloy 80 is ideal, supplied as boxed ring cores for differential transformers. Magnetics is also the only producer of both ferrite cores and silicon-iron strip wound cores which meet the various circuit requirements of the ground-to-neutral transformers. All cores are quality-tested from raw material to finished product.

For more information on GFI cores, ask for Magnetics Bulletin RC-1. Write Magnetics, Components Division, Butler PA 16001.

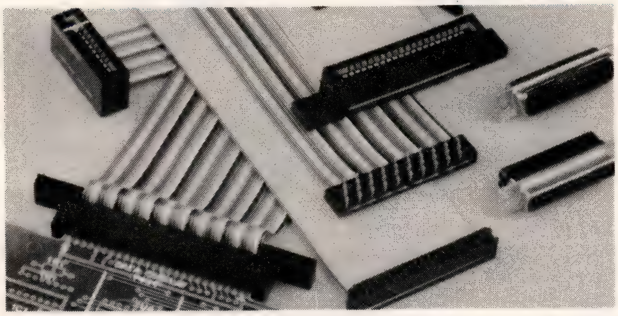
Very special specialists in GFI cores.

MAGNETICS
A DIVISION OF SPANG INDUSTRIES INC

CIRCLE 142

SAE

Multi-Term tm



SAE's Multi-Term line of IDC connectors and cable offer a tremendous variety of mass termination components and options including jumper assemblies and cable harnesses.

- Five major connector styles — socket, DIP, PCB, "D" subminiature, edgeboard.
- Exclusive dual locking barbs on each contact.
- Grey or multi-colored laminated ribbon cable — available in 26, 28 or 30 AWG.
- Delivery from stock — consult your local SAE Distributor.

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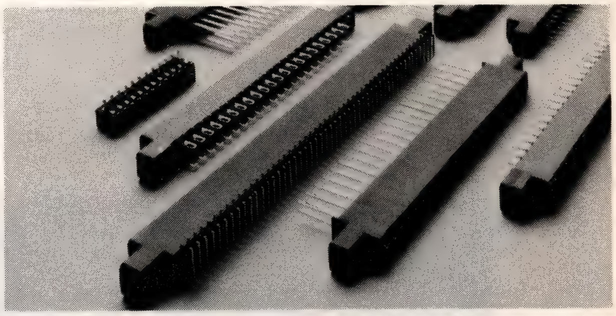
Stanford Applied Engineering
340 Martin Avenue
Santa Clara, California 95050
(408) 988-0700

Edgeboard Connectors



SAE's broad line of edgeboard connectors offer a wide variety of contact spacing, plating options, contact designs and termination configurations.

- Economy edgeboard connectors with .100", .125", .156" contact spacing. Dip solder terminals and extra large chamfer board entry make this series perfect for low cost requirements.
- MODCON tm series modular high density receptacle connector designed for board-to-board interconnect applications. Features contacts that mate with conventional .025" x .025" wiring posts on .100" or .150" center-to-center spacing.
- And more, more! Pierced eyelet terminals — individual contacts — single or double row contacts to name just a few.

For free catalog on complete switch line, circle Reader Service number, or write

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340 Martin Avenue
Santa Clara, California 95050
(408) 988-0700

CIRCLE 86

Ammeters go foreign with 50-Hz adapter

A clamp-on adapter, Model 10-E, adapts a variety of ammeters for 50-Hz amperage readings. Line loads from 0 to 300 A can be measured instantly, accurately and safely, without interrupting the circuit. A handy thumb/slide switch selects ammeter ranges of 0 to 6, 12, 30, 60, 120 and 300 A at ±3% accuracy. The adapter operates with Models 310, 630, 630 PLK and 60 testers.

Triplett, One Triplett Dr., Bluffton, OH 45817. (419) 358-5015. $33.

CIRCLE 330

Serial bus analyzer tests 1553 data systems

A multifunction serial bus analyzer, SBA, tests military standard 1553 data bus systems. The portable troubleshooting, network analysis and simulation device is primarily designed for avionic equipment operating on the internal time-division command/response multiplex data bus. The tester performs the continual test requirements on both A and B versions of the 1553 bus. SBA monitors and records both transmit and receive data; it checks basic information and flags errors for each active remote terminal on the bus.

Conic Data Systems, 9020 Balboa Ave., San Diego, CA 92123. (714) 279-0411.

CIRCLE 331

Tester simulates power interruptions

A single-phase power failure simulator, PLM-103P, gives accurate control of the turn-on angle. The device tests any type of equipment up to a maximum of 15 A rms on power lines from 115 to 240 V rms. Power interruption can be from 1/2 cycle to 999 half cycles, controlled by an operator with manual or auto mode. Power interruption occurs at current zero-crossing to the load. Power restoration occurs from 1 to 179 degrees.

Bermar, 115 Vine St., Nashua, NH 03061. (603) 888-1300. $890; 2 to 4 wks.

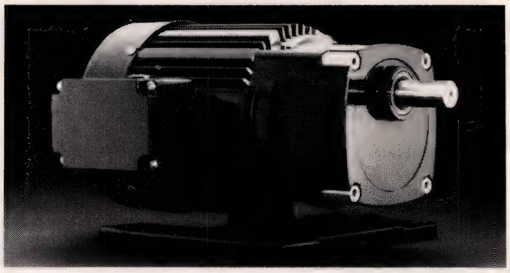
CIRCLE 332

Metric Motors/Gearmotors from Bodine

Meet a new foreign power: metric motors from Bodine. The first American motors made to perform overseas.

For 75 years, Bodine has been the leader in fractional horsepower motors. And our experience shows in our new full range of 62 metric motors and gearmotors designed for 1-170 output watts, 220/240 V, 50 Hz power input. Each is engineered to meet most international standards for safety and performance.

You'll also appreciate our foreign service. Our established international Distributor network ensures you a ready supply of Bodine products whenever and wherever you need them. At home or abroad, you can depend on Bodine.



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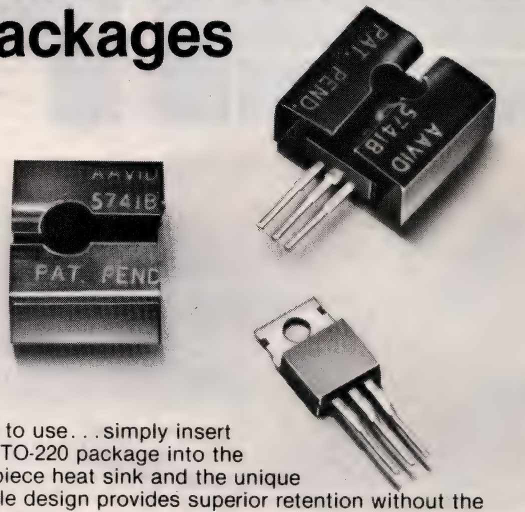
CIRCLE 87

Low-cost/Clip-on Heat Sink for TO-220 Packages



Easy to use...simply insert your TO-220 package into the one-piece heat sink and the unique dimple design provides superior retention without the need of any accessory hardware. The entire assembly can be mounted vertically for those applications where space is at an absolute premium. Low-cost 5741 heat sinks available in black anodize or gold chromate finish.

Write today for free samples and our catalog describing the most extensive line of heat sinks in the industry.

AAVID ENG. INC.

AAVID ENGINEERING, INC.
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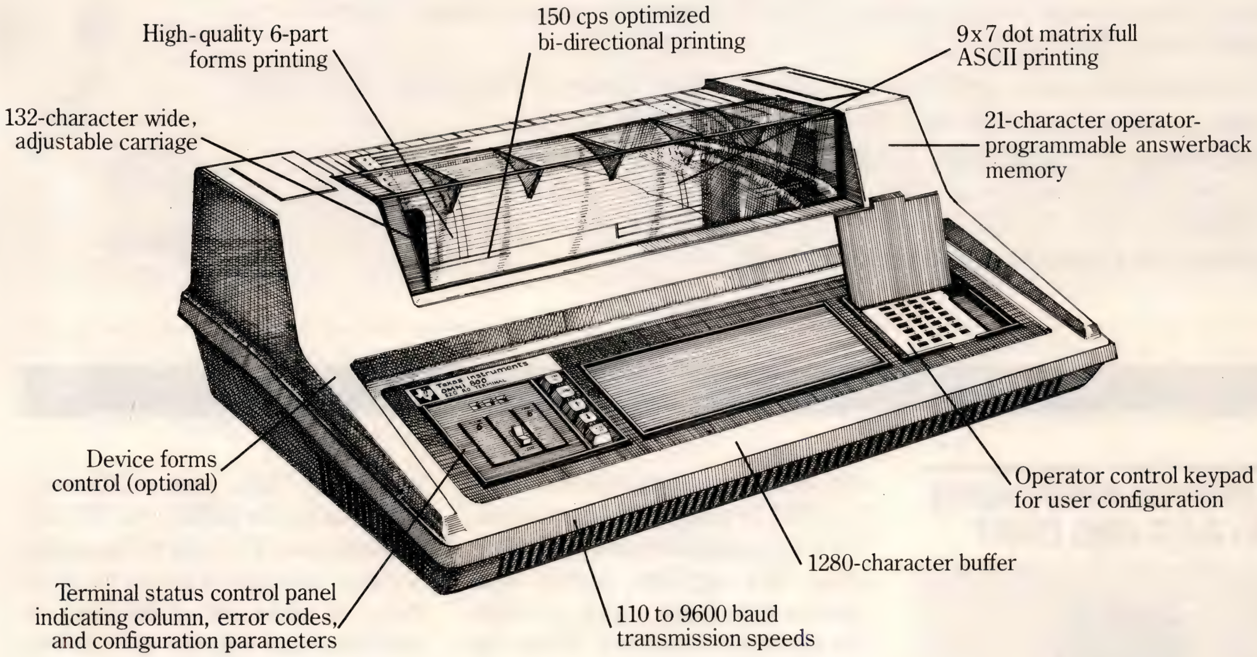
CIRCLE 88

IMMEDIATE DELIVERY

The Associate Producer.

820 RO

Receive-Only Printer


High-quality 6-part forms printing
150 cps optimized bi-directional printing
9x7 dot matrix full ASCII printing
132-character wide, adjustable carriage
21-character operator-programmable answerback memory
Device forms control (optional)
Operator control keypad for user configuration
1280-character buffer
Terminal status control panel indicating column, error codes, and configuration parameters
110 to 9600 baud transmission speeds
Texas Instruments OMNI 800 820 RO TERMINAL

The OMNI 800* Model 820 RO Printer has the same designed reliability as its associate, the 810 RO. With more standard features and options like expanded and compressed printing, the 820 RO offers greater flexibility for additional applications. And, should application needs change, the 820 RO is easily upgraded to a KSR model for a modest cost. The productive 820 RO Printer has all the quality and performance you associate with the OMNI 800 Family.

TI is dedicated to producing quality, innovative products like the Model 820 RO Printer. TI's hundreds of thousands of data terminals shipped worldwide are backed by the technology and reliability that come from 50 years of experience, and are supported by our worldwide organization of factory-trained sales and service representatives.

For more information on the 820 RO, contact the TI sales office nearest you or write Texas Instruments Incorporated, P.O. Box 1444, M/S 7784, Houston, Texas 77001, or phone (713) 937-2016. In Europe, write Texas Instruments Incorporated, M/S 74, B.P. 5, Villeneuve-Loubet, 06270, France.

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CIRCLE 89

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Specialists in beryllium copper since 1938

CIRCLE 90

INSTRUMENTS

μC speeds autoranging in 3-1/2 digit DMM

A microcomputer, built into the 3-1/2 digit multimeter Model 2845, automatically selects the proper range without the slow "hunting" action common to some earlier autoranging meters. Once the 2845 is connected to a circuit, the microcomputer instantly analyzes the applied signal and selects the range which provides the greatest resolution. When the input level exceeds the range in use, an "auto-skip" feature puts the meter on the next highest range. Range selection is performed by ultra-low power reed relays. Basic dc accuracy of the unit is 0.1%. The LCD digits measure 0.5 in.

B&K-Precision, 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087. $175. **CIRCLE 333**

Bus interface links time/amplitude test set

A time and amplitude test set, Model 6125C-Option 60, adapts to automatic test and calibration systems via its IEEE-488-1978 interface bus. The portable, lightweight instrument performs a variety of tests for calibration of oscilloscopes (up to 500 MHz), digital frequency counters, spectrum analyzers and basic voltmeters. Voltage calibration, main and delayed sweep calibration, rise-time calibration, frequency calibration and related measurements can be achieved at automatic testing speeds to reduce test time and expense. Various controllers can be used, including the Tektronix 4051, the Hewlett-Packard 9825, the Wang 220 and the Commodore PET. Although designed for operation in an ATE system, Model 6125C-Option 60 offers large LED displays and an easy-to-use panel layout for convenient manual operation.

Ballantine Laboratories, P.O. Box 97, Boonton, NJ 07005. (201) 335-0900. $5950; 4 to 6 wks.

CIRCLE 334

Function generator takes to the field

A function generator providing outputs from 0.1 Hz to 1 MHz, Model 420, operates away from the ac line using rechargeable, NiCd batteries. Sine, triangle and squarewave outputs are available as well as dc and TTL logic outputs. Signal amplitude is 10-V pk-pk into a 600-Ω load, and is continuously variable by more than 30 dB. The 420 also has continuously variable dc offset. Frequency accuracy is ±3% of full scale from 1 Hz to 100 kHz. Sinewave distortion is less than 1% over a 1 Hz to 100-kHz range. An external voltage can be used to control generator output frequency. Model 420D is designed for ac or battery operation while Model 420A operates from the ac line only.

Simpson Electric, 853 Dundee Ave., Elgin, IL 60120. (312) 697-2260. $175 (420A); $210 (420D).

CIRCLE 335

Logic analyzer prompts user

A 40-channel logic analysis system, PI 540, guides the user in the selection and setup of the best analyzer configuration. The instrument is capable of logic state, logic timing and waveform recording functions. All functions operate interactively as a total data system or as independent analysis units. PI 540 is housed in a System 5000 mainframe with a central processor, a 9-in. raster-scan CRT, a protected folding keyboard and analyzer software. Ten differential configurations are available to combine 32 channels of state, eight channels of timing and one analog recording channel.

Paratronics, 122 Charcot Ave., San Jose, CA 95131. (800) 538-9713. $5900 to $8900; 8 wks.

CIRCLE 336

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The wide variety of Instrument Specialties beryllium copper contact strips and contact rings in many sizes and shapes can help you solve your shielding and grounding problems. Standard and catalog items work for most applications, but special adaptations are easily made and provide you with virtually a custom-designed part with only a one-time extra charge.

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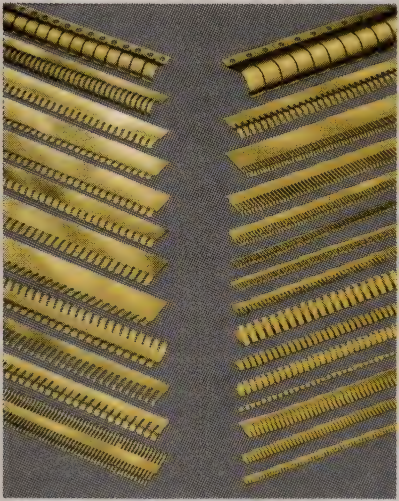
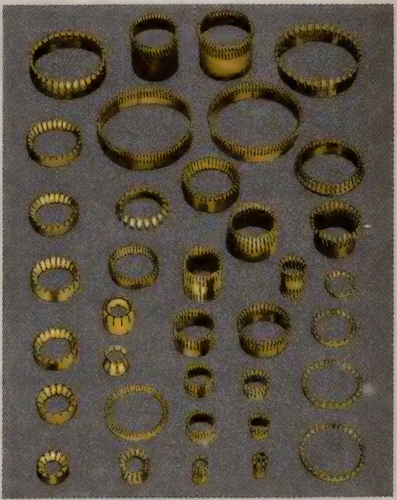


34 strips, various configurations:
Assortment 97-272 ... $30.00



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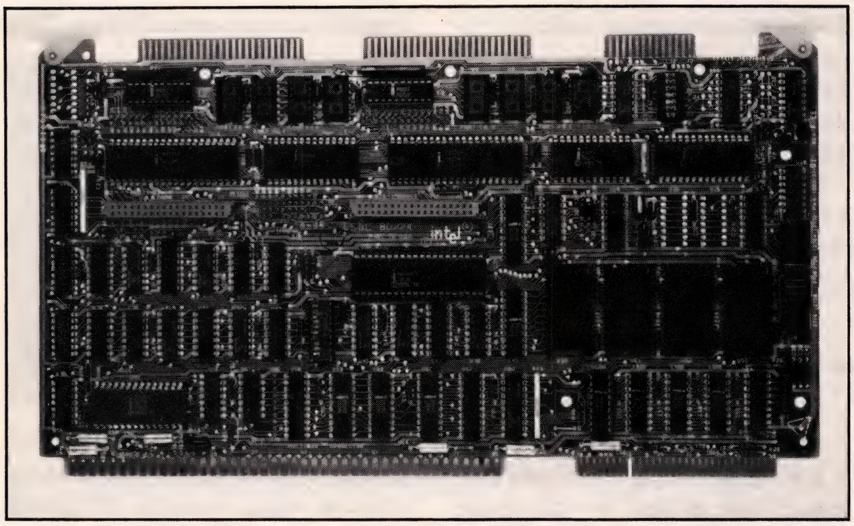
CIRCLE 91

Single-board computer operates with dual clock



Built around an 8085A CPU, the iSBX 80/24 single-board computer contains 4 kbytes of static read/write random-access memory on its 6.75 × 12-in. board.

The iSBX 80/24—a complete computer system on a single 6.75 × 12-in. printed-circuit board—contains full interface logic for Multimaster configurations and two on-board bus connectors for expansion. Its 8085A-2 CPU can operate at a choice of two speeds: either 4.8 or 2.4 MHz.

The 8-bit 8085A-2, which is software compatible with the Intel 8080A CPU, contains six 8-bit general-purpose registers and an accumulator. Along with the CPU, the board holds a clock, the iSBX bus interface, read/write memory, read-only memory sockets, I/O ports and drivers, serial communications interface, priority interrupt logic and programmable timers. Multibus logic interfaces the board with Intel's family of single-board computers, expansion memory options, digital and analog I/O expansion boards, and peripheral and communications controllers.

The iSBX bus interface allows incremental board expansion through two multimodule connectors for plug-ins. The iSBX 350 parallel I/O multimodule board provides 24 I/O lines using a 8255A programmable peripheral interface. Therefore, two iSBX modules together with the iSBX bus furnish up to 96 lines of programmable I/O.

Alternatively, a serial port may be added using the iSBX 351 serial I/O multimodule board. Math may be configured on-board with either the iSBX 332 floating-point math or the iSBX 331 fixed/floating-point math multimodule board.

The 80/24 contains 4 kbytes of static read/write memory. In addition, the on-board RAM capacity may be expanded to 8 kbytes with the iSBX 301 4-kbyte RAM Multimodule board. All read and write operations are performed at maximum processor speed. In single quantities, the 80/24 costs $1095 and the iSBX 301 costs $3250. Both products are available now.

Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. (408) 734-8102, ext. 598.

CIRCLE 307

Embedded formatter controls 4 drives

An IBM/ANSI-compatible embedded tape formatter, Model 700, provides control for up to four tape drives from a single controller. The board operates at data densities of 1600 bits/in. in PE and 800 bits/in. in NRZI. The unit also provides all the necessary logic for writing and reading in either PE or NRZI formats. Model 700 performs all tape drive operations, including motion control, preamble and postamble generation and check and IRG and file mark generation. All critical clock and delay times are derived from a crystal-controlled oscillator.

Perkin-Elmer Memory Products, 7301 Orangewood Ave., Garden Grove, CA 92641. (714) 891-3711. $1475 (100 qty); 8 to 9 wks.

CIRCLE 337

Converter stores data in buffer memory

Procon III, a data-merging protocol converter, converts 2770 bisynchronous data to an asynchronous format. The board stores up to 32 kbytes of error-free data in its buffer store memory. Asynchronous and bisynchronous data input can share a common computer or terminal input port. The bisynchronous protocol provides CRC error checking with automatic retransmission of data blocks in which errors have been detected. Only error-free data is stored in memory. The Procon III is suited for merging dedicated phone line wire service data with a dial telephone link. A companion unit, Model BSD-32/0, converts asynchronous data to 2770 protocol.

Epic Technology, 2730 N.W. First Ave., Boca Raton, FL 33432. (305) 391-8390.

CIRCLE 338

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for miniature audio and pulse transformers.

Our DO-T and DI-T transformers deliver more power for their size than any competing product on the market.

Compare us to competitors. Match the claimed ratings against the power the products actually deliver. Our DO-T 10, for example, delivers 100mw @ 5% distortion @ 300Hz. Identical measurements taken on a leading competitor's equivalent rated at 50 mw @ 300Hz revealed an actual delivered power *less than lmw @ 7% distortion.*

Check into TRW/UTC DO-T and DI-T transformers today. For fast, off-the-shelf delivery, see your local TRW/UTC distributor. Or contact TRW/UTC, an operation of TRW Inductive Products, 150 Varick Street, New York, N.Y. 10013. (212) 255-3500.

STANDARD AUDIO TRANSFORMER AND INDUCTOR SELECTION GUIDE

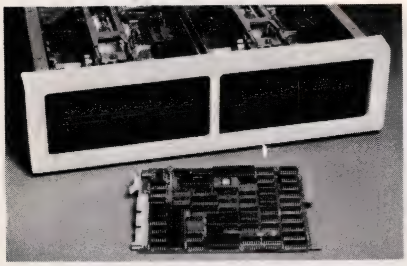
Product Series	Description	Weight	Nominal Size	Freq. Range	Max. Power
MILITARY TYPES: GRADE 5, METAL ENCASED					
BIT-250	Ribbon style Kovar leads; compatible with transistor and IC flat pack styles. Transformers and inductors.	.040 oz. (1.13 gm)	.25 in. d x .25 in. h (6.4mm d x 6.4mm h)	300 Hz to 250 kHz	80 mW @ 1 kHz
DO-T	Flexible 1½" Plated Dumet leads. Ultraminiature transformers and inductors for transistor circuitry.	.100 oz. (2.84 gm)	.31 in. d x .41 in. h (7.9mm d x 10.3mm h)	300 Hz to 20 kHz	500 mW @ 1 kHz
DO-T200	Plug-in — TO-5 pattern. Ultraminiature transformers and inductors for transistor style circuitry.	.125 oz. (3.54 gm)	.35 in. d x .56 in. h (8.9mm d x 14.3mm h)	300 Hz to 20 kHz	100 mW @ 1 kHz
DI-T	Flexible 1½" Plated Dumet leads. Ultraminiature transformers and inductors for transistor circuitry.	.067 oz. (1.89 gm)	.31 in. d x .25 in. h (7.9mm d x 6.4mm h)	400 Hz to 100 kHz	500 mW @ 1 kHz
DI-T200	Plug-in — TO-5 pattern. Ultraminiature transformers and inductors for transistor circuitry.	.067 oz. (1.89 gm)	.31 in. d x .38 in. h (7.9mm d x 9.5mm h)	400 Hz to 100 kHz	500 mW @ 1 kHz

TRW INDUCTIVE PRODUCTS

FROM A COMPANY CALLED TRW

CIRCLE 92

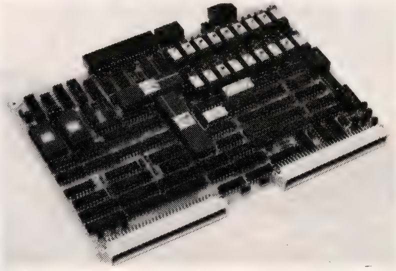
Floppy controller adapts to media



A floppy-disk controller card, F02CTR, identifies a drive and disk formats—all automatically. The controller emulates DEC's RX02 and plugs directly into an LSI-11 backplane. The controller identifies a drive as either one or two-headed and establishes the correct stepping rate and other control signals. In addition, the F02CTR automatically recognizes single or double-density formats. A 512-byte hardware bootstrap is built into the controller's LSI-11 interface section. The bootstrap program loads system software automatically from a single or double-density diskette, eliminating need for a separate bootstrap board.

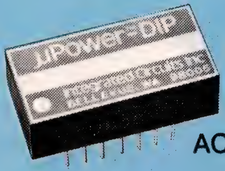
Advanced Electronics Design, 440 Potrero Ave., Sunnyvale, CA 94086. (408) 733-3555. $1170; 4 wks. **CIRCLE 339**

MPU works alone or as peripheral master



A microcomputer board, based on the Z8001 microprocessor, functions as a stand-alone microcomputer or as the master in a set of several peripheral boards. The Z8000-MPU's economical stand-alone performance is made possible by 32 kbytes of on-board RAM with parity protection, 8 kbytes of additional ROM or PROM space, two flexible communication channels and a real-time clock for managing multitasking software environments. The board uses a Z80A-SIO controller to incorporate two, high-speed channels for a communications subsystem without the need for additional boards. Each channel is individually programmable to support synchronous or asynchronous protocols. Other features include a parity-error detection circuit, pin and socket connectors, three types of interrupts and three LED displays to indicate CPU status.

Zilog, 10340 Bubb Rd., Cupertino, CA 95014. (408) 446-4666. $2295. **CIRCLE 340**



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As hard as we tried, we couldn't shrink our new line of micro-miniature DC-to-DC converters any smaller than we've shown above...actual size. So, if you've been trying to fit one of those maxi-sized converters onto your PC board, then take a look at our new **µPower™DIP** converters!

The specifications are excellent, by anyone's standards...and conservative, too. **µPower™DIP** converters are available with input voltages of 5, 12, 24, 28, 48 or 50. Dual Tracking Regulated Outputs with isolation >100 Megohms @ 500VDC and Non-isolated Dual Regulated/Unregulated Outputs are available in voltage ranges of 5, 12 and 15 with up to 1.5 Watts out. Efficiencies range from 55 to 80%, to keep you ahead of the game!

But, you say your circuit runs off a battery supply?
µPower™DIP converters are also available with an input variance of +3 to +7VDC...just perfect for those battery applications and they can provide up to 1.25 Watts out at an efficiency up to 80%. And they're not expensive, either.

Thick-film hybrid micro-electronics, made in the U.S.A. No short-cuts and they're practically fool-proof.

If you've got a converter need...
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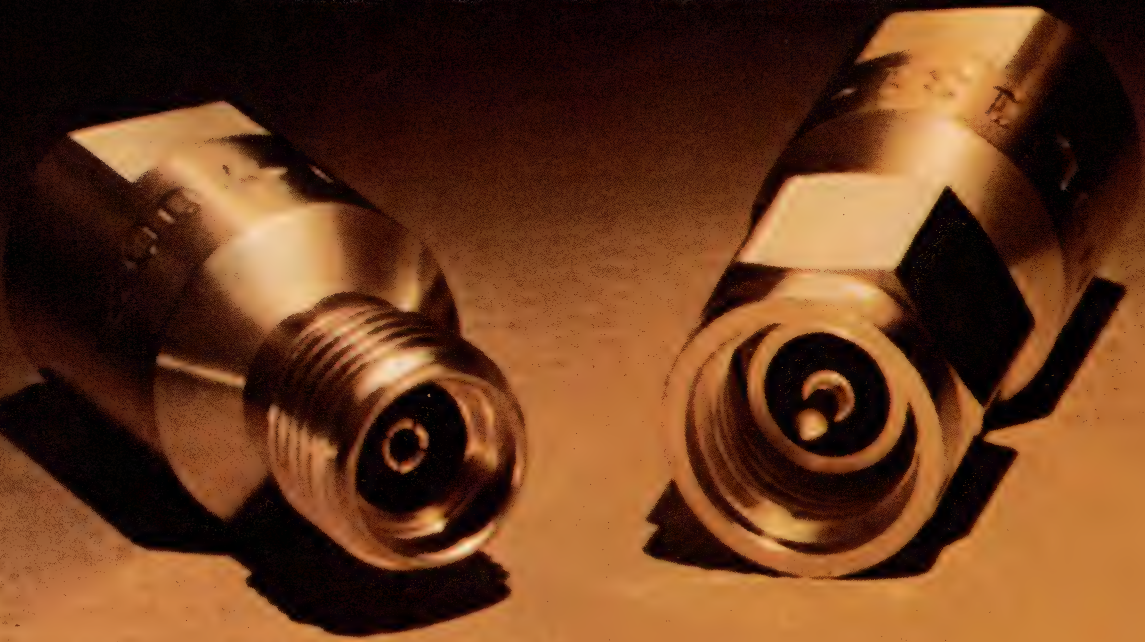
CIRCLE 93

Resonance-Free to 34 GHz.



Affordable Amphenol® APC-3.5™ Connectors: When performance is critical above 18 GHz.

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APC-3.5
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Adapters,
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Amphenol APC-3.5 Connectors bring coax convenience to the traditional waveguide system. A wide choice of plugs, jacks and adapters that exhibit resonance-free, low VSWR performance to 34 GHz is available. All at a price low enough for their use in typical applications.

The rugged APC-3.5 has a wide (.020-in.) radial shoulder on the outer conductor that provides high reliability and repeatability after hundreds of matings.

Low leakage is assured because of the high contact force that can be applied to the wide gold-plated beryllium-copper shoulder.

The APC-3.5 can improve performance of existing systems merely by changing from SMA connectors. No system redesign is necessary, since the APC-3.5 mates directly with the SMA connectors.

For more information, call the sales office or distributor nearest you.

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CIRCLE 101

Tester automatically gives go/no-go to isolate faults

A portable go/no-go tester quickly isolates data-comm network problems to the malfunctioning element. By simulating either the data-comm or data-terminal equipment, as needed, Tektronix's programmable 834 Data Comm Tester verifies the performance level of individual network elements or of a complete data communications channel.

The instrument performs many standard error-checking procedures, including those for bit and block error rates, 16-bit cyclic redundancy, 8-bit longitudinal redundancy and 16-bit blocks.

For convenient operation in the field, the 834 uses a family of ROM packs containing test routines for common line protocols. The ROM packs can be preprogrammed at the factory for the test set and program sequence to troubleshoot specific equipment. After inserting the appropriate ROM pack, the service technician calls the program into the set and presses the START key. The instrument does the rest automatically.

The program sequence in the test set is programmable in response to commands such as: Compare; Wait; Halt; Send; Receive; Jump.

The set is configurable to match the parameters of many data-comm networks. The operator can select general synchronous or asynchronous operation or HDLC protocol control.

Data rates up to 19.2 kbits/s, full or half-duplex operation, Hex, ASCII, EBCDIC or user-defined codes are available by pressing a button that scrolls through the choices. The base price of the 834 is $3700; delivery is in August.

Tektronix, Marketing Communications Dept., P.O. Box 1700, Beaverton, OR 97075. (1-800) 547-1512.

CIRCLE 303

THE NEW TIME MACHINE

Real-Time Transient Storage
with the new LeCroy WD8256 Waveform Digitizer. For under $5,000*, you can now analyze complex and fast transient signals with the precision of instruments selling for over twice the price of LeCroy's WD8256. And with advanced features you won't find elsewhere, whatever the price:

■ 25 ps aperture certainty ■ 20 megaword/second digitizing rate ■ GPIB, RS-232C and parallel binary I.O. ■ Data transfer to 5 megaword/second ■ Chart record and display outputs ■ Pretrigger recording ■ Digital signal offset ■ Digital trigger delay ■ Microprocessor instrument control ■ Automatic self-test and diagnostics
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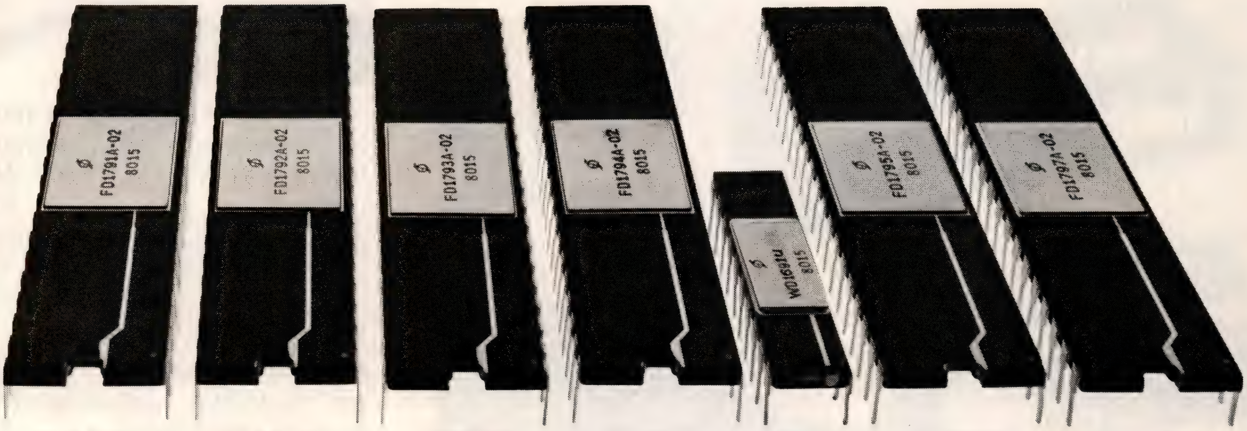
The ONLY Family that delivers complete Floppy Control.



Double Density Inverted Bus

Single Density Inverted Bus

Double Density True Bus

Single Density True Bus

Floppy Support Logic

Double Density Double-Sided Inverted Bus

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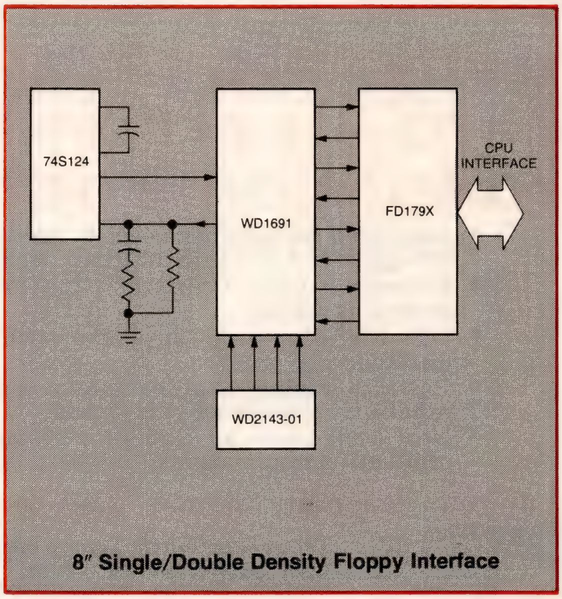
Everything you've always needed to interface with a floppy

Western Digital's 179X Family of Floppy Disk Controllers provide the flexibility needed to interface with single and double-density Drives. Whether you choose IBM or non-IBM formats, mini-floppy or 8″ drive, single-sided or double sided, we have the controller to do the job. And with its 11 powerful macro-commands, your CPU can spend more time processing the data it reads, rather than trying to read it.

WD1691 Reduces board space

With our new WD1691 Floppy Support Chip, we've reduced your component count even more. A Phase-Lock-Loop data separation and write precompensation circuits are provided, reducing discrete logic to a minimum number of components. The 179X, 1691, and 2143 clock generator are all offered as a chip set. The results are lower component costs, less board space, less design time, and a higher degree of reliability.



8″ Single/Double Density Floppy Interface

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WESTERN DIGITAL

3128 Redhill Avenue, P.O. Box 2180, Newport Beach, CA 92663 ● (714) 557-3550

CIRCLE 103

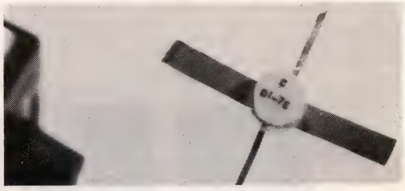
Downconverter pulls in satellite video

An earth terminal downconverter, ACA-4200, accepts satellite downlink signals in the 3.7 to 4.2-GHz band. The unit is optimized for satellite-relayed video standards of 36-MHz video bandwidth with a 6.2 or 6.8-MHz FM aural subcarrier. Nominal conversion gain is 11 dB; SSB noise figure, 13.5 dB. The downconverter includes a ×4 local oscillator multiplier. The user supplied +9.5 dBm LO signal is in the 800-MHz range for better stability and lower noise. Front-end bandpass filters minimize out-of-band response and generally eliminate the need for additional preselection.

Avantek, 3175 Bowers Ave., Santa Clara, CA 95051. Jim Lindauer (408) 727-0700. Under $1000 (small qty); 8 to 9 wks.

CIRCLE 354

Rf transistor supplies 40 W for mobile use



A six device rf transistor family, designated DMB, supplies from 5 to 40 W for use in 800-MHz transmitters and cellular telephone systems. Each device operates from 12.5 V and provides full output over the entire 806 to 866-MHz band. Since the transistors are common-base devices with input matching, designing with them is simplified.

Communications Transistor, 301 Industrial Way, San Carlos, CA 94070. (415) 592-9390.

CIRCLE 355

Modems take data on metallic/optic paths

Stand-alone data links, for in-house and in-plant interconnection, use Bit-Driver hard-wire or fiber optic modems. The short-haul modems offer simplex and duplex asynchronous communications at data rates up to 56 kbits/s. Range is up to 15,000 ft for metallic links and up to 6000 ft for optical routes. RS-232C molded cable assemblies and metallic or fiber optic interconnecting cables are available. Cost of a complete system is dependent on the type and length of interconnecting cable.

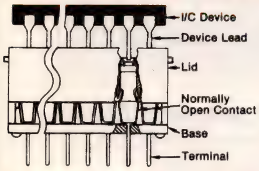
Belden, P.O. Box 1327, Richmond, IN 47374. (317) 966-6661. $195 (wire); $280 (optical).

CIRCLE 356

Costly I/Cs Need Our "Zero-Insertion-Force" Production Sockets!

- Improved socket opens easily, retains device with 50% greater force than original design!
- No tools — or screwdrivers — necessary for opening or closing socket.
- I/Cs literally "drop" into open socket — no lead damage!
- Positive-wiping, dual-leaf contacts provide true reliability when socket is closed.
- New design now available for 24- and 40-lead production applications.

The device literally "drops" into position!



Unique, patented, 2-piece construction of the new "504" socket lets you "drop" your device into open contacts. To close contacts completely, simply push the socket lid down to the base. You get a retention force of over 75 grams per pin! Yet the "504" socket is easy to open — no tools or screwdrivers are necessary.

Welcon™

Call 219/287-5941 for info about our Series "504" Socket

WELLS ELECTRONICS, INC., 1701 S. Main, So. Bend, Ind.

CIRCLE 104

Push-pull VMOS FETs push power to 200 MHz

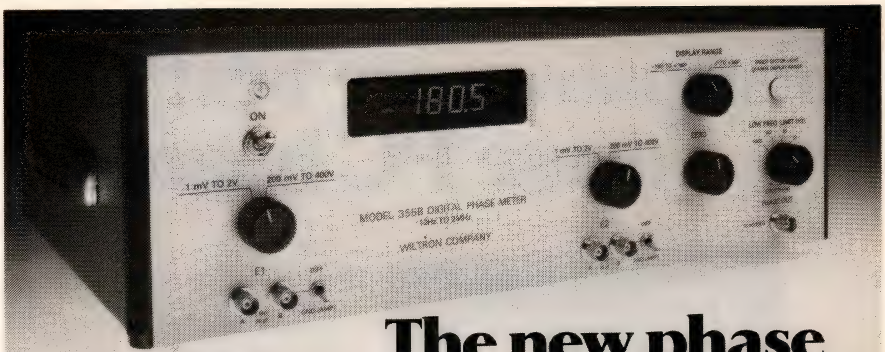
Three rf power devices combine the advantages of VMOS design with the benefits of a push-pull configuration. The devices operate from 2 to 200 MHz, delivering 120 W (DV1112), 80 W (DV1111) and 40 W (DV1110). All three can be operated in Class A, B or C service. The push-pull design cancels even-order harmonics. VMOS devices give high efficiency, a low noise figure and the ability to withstand an infinite VSWR. In addition, the problem of thermal runaway is eliminated. VMOS circuits can be paralleled without fear of current hogging. Two VMOS transistors in one push-pull package reduce amplifier size and allows direct connection of impedance matching transformers.

Siliconix, 2201 Laurelwood Dr., Santa Clara, CA 95054. (408) 988-8000. $96 (DV1112); $64 (DV1111); $32 (DV1110) (100 qty); stock. **CIRCLE 413**

Matched optic data link ties computers together

Hybrid fiber optic transmitter and receiver modules, HLT-10 and HLR-10, simplify the design of data links between minicomputers. A user simply screws a terminated fiber cable into the modules to complete installation. Data link bandwidth is 10 kbits/s to 10 Mbits/s at a distance of up to 2 km on single-fiber cables. The modules mount directly to a PC board. Basic Manchester encoding satisfies input requirements. TTL buffering allows direct connection to existing logic circuitry.

Galite, 2 Tower Dr., Wallingford, CT 06492. (203) 265-7126. **CIRCLE 414**



The new phase meter to take the fourth dimension digitally.

It's a Wiltron.

Wiltron's Model 355B Digital Phase Meter accurately measures the phase difference between two signals. Signal frequencies can fall anywhere between 10 Hz to about 5 MHz with performance specified to 2 MHz. Measurement accuracy is typically within 0.1°

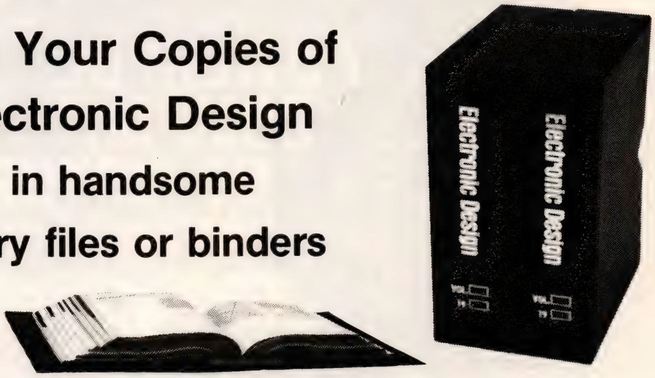
Two signals of greatly varying amplitudes can be measured over a combined dynamic range of 112 dB, 66 dB (1mV to 2V or 0.2V to 400V) per channel.

For maximum accuracy, an error sector indicator guides the user to select the appropriate display range. Measurements are always made at optimum test settings. Display is 4-digit LED. A voltage proportional to phase output is provided for remote displays.

Price of the Model 355B is $2150. For complete information, address Wiltron, 825 E. Middlefield Road, Mountain View, CA 94043.
Phone (415) 969-6500. TWX 910-379-6578.

WILTRON

CIRCLE 105



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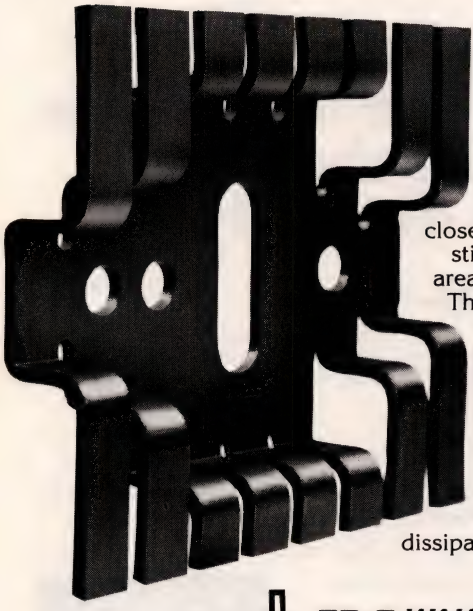
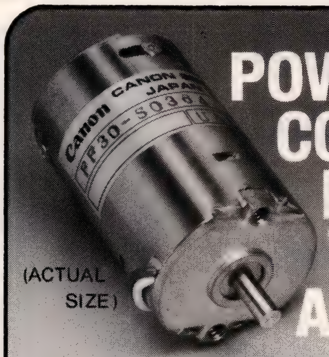


Low profile, high dissipation heat sinks from E G & G Wakefield Engineering are ideal for applications where TO-3, TO-66, or TO-220's are mounted on crowded PC boards. The unique shape of these heat sinks permits closer component placement while still providing maximum surface area for excellent heat dissipation. These aluminum alloy heat sinks are available in either plain or black anodized and provide the highest power dissipation per unit cost. Compatible with both metal and plastic cased semiconductors. Currently in-stock and competitively priced. That's why . . . if it has to do with heat dissipation . . . people throughout the electronics industry call us.

EG&G WAKEFIELD ENGINEERING
60 Audubon Road, Wakefield, MA 01880 617/245-5900

CIRCLE 106



POWERFUL COMPACT DC MOTOR WITH AC TACH

Available in OEM quantities, the FF 30 DC motor with integral 8 Hz AC tachometer provides high efficiency, long life and low electrical interference and mechanical noise. Available with AMP 110 terminals. 30mm dia., 48mm long.

- *Varistor ring and high quality brush material for low electrical noise*
- *2 V rms AC tach output controls speed*
- *Maximum efficiency more than 60% at 12V*
- *7 slot core for smooth operation*

SPECIFICATIONS

Rated Voltage:	12V	No Load Current:	115 mA
Rated Load:	75g-cm	Starting Torque:	280 g-cm
Rated Speed:	4700 ± 500 rpm	Stalled Current:	1800 mA
No Load Speed:	6450 rpm	Motor Regulation:	23 rpm/g-cm
		Rotation:	CCW

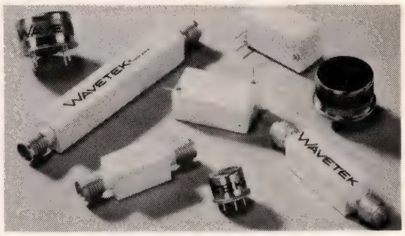
For complete technical information:

Canon

Canon, U.S.A., Inc.
Electronic Components Div.
10 Nevada Drive,
Lake Success, N.Y. 11042
516/488-6700 Telex: 96-1333
Cable: Canon USA LAKS

CIRCLE 107

Tiny filters save circuit space



Ultramin Series filters require little space on crowded circuit boards. Designs are available in bandpass, low-pass, high-pass and bandstop types in TO-5, TO-8, stud-mount and rectangular metal packages. Frequency range is 10 to 1000 MHz. A 12-section filter occupies only 0.31 in.^{3} of space. A typical 0.01-dB Tchebychev or Butterworth response is standard with Guassian, Bessel or linear phase responses available on special order. Bandpass filters are offered with 3-dB bandwidths from 2 to 70% of center frequency. The requirements of MIL-E-5400 and MIL-STD-202 are met.

Wavetek, 66 N. First Ave., Beech Grove, IN 46107. (317) 783-3221. CIRCLE 357

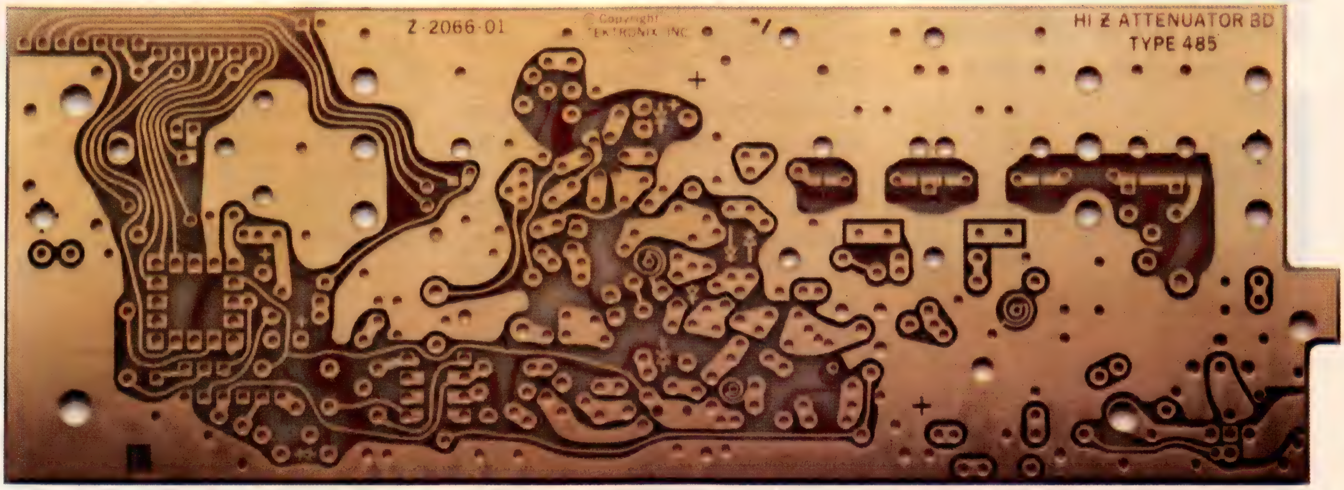
DTMF filters give designers a choice

Two DTMF group filters offer the designer a choice of built-in hard limiting (3040/41A) or a filter without a limiter (3044/45). Both types work with most digital detectors, including Rockwell's CRC-8030, Mitel's MT 8820 and Mostek's MK 5102. The 8-pole bandpass filters (one each for low and high group) feature wide dynamic range, more than 40-dB attenuation between groups, greater than 55-dB dial-tone rejection and less than 2-dB passband ripple.

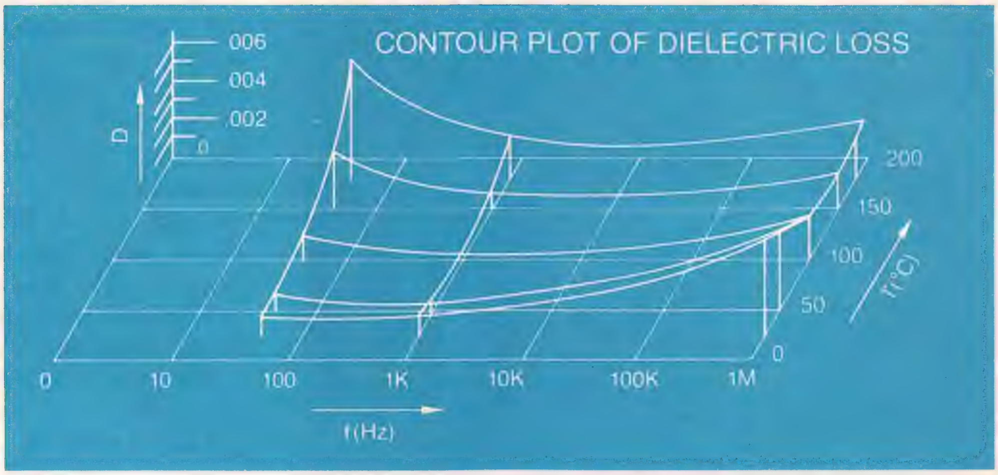
ITT North Microsystms, 700 Hillsboro Plaza, Deerfield Beach, FL 33441. (305) 421-8450.

CIRCLE 358

POLYSULFONE PCB SUBSTRATE GIVES



PERFORMANCE CLOSE TO PTFE/GLASS,



AT A PRICE CLOSER TO EPOXY/GLASS

When you're looking for high performance in PCB's—particularly in high frequency applications—a polysulfone substrate can give it to you at far less cost than PTFE/glass. Polysulfone has excellent electricals: low dielectric constant and low dissipation factor for low loss (see graph). It withstands hand and wave soldering (500°F. bath for 5 seconds).

Polysulfone can be easily extruded for PCB substrate, and easily drilled. Copper-clad laminate of polysulfone has good peel strength and low z axis expansion. It can be processed by subtractive, semi-additive and fully additive processes. (Copper-clad sheet is available from Norplex.)

You can also *mold* polysulfone for PCB's with standoffs, holes of all sizes, and in almost any shape—to save finishing and machining time.

And cost is modest. Tektronix saved $120,000 annually by switching from polyphenylene oxide to extruded UDEL® Polysulfone.

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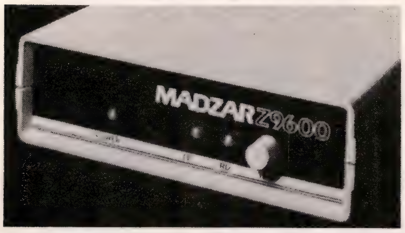
CIRCLE 108

Modem takes 9600 baud data up to 10 miles



An asynchronous modem for short-haul data communications, Model Z9600, sends 9600 bits/s data up to 10 miles. The unit automatically adjusts to baud rates and indicates transmit/receive status. Self-test and provision for RS-232 interface are included. Model Z9600 has provision for two-wire and four-wire hookup with simplex or full and half-duplex operation over telephone or private lines. Power requirement is 120 V ac, with 220-V, 50-Hz operation available as an option. Cabinet and rack-mounted versions are available.

Madzar, 37490 Glenmoor Dr., Fremont, CA 94536. (415) 794-7400. $117 (50 qty); 4 wks.

CIRCLE 359

Direct-connect modem works without operator

A direct connect modem, M103-A, receives and transmits information automatically, without the aid of a terminal operator. A data link can be established during early morning or evening hours to reduce phone costs. The originate, answer, auto-answer modem is compatible with Bell 103A and 113B modems and connects directly to the telephone network via an RJ11C modular phone jack. The unit operates from 0 to 450 baud and connects to terminals through an RS-232 or 20-mA interface.

Modtech, 1958 Helsinki Way, Livermore, CA 94550. (415) 447-9349. $316.

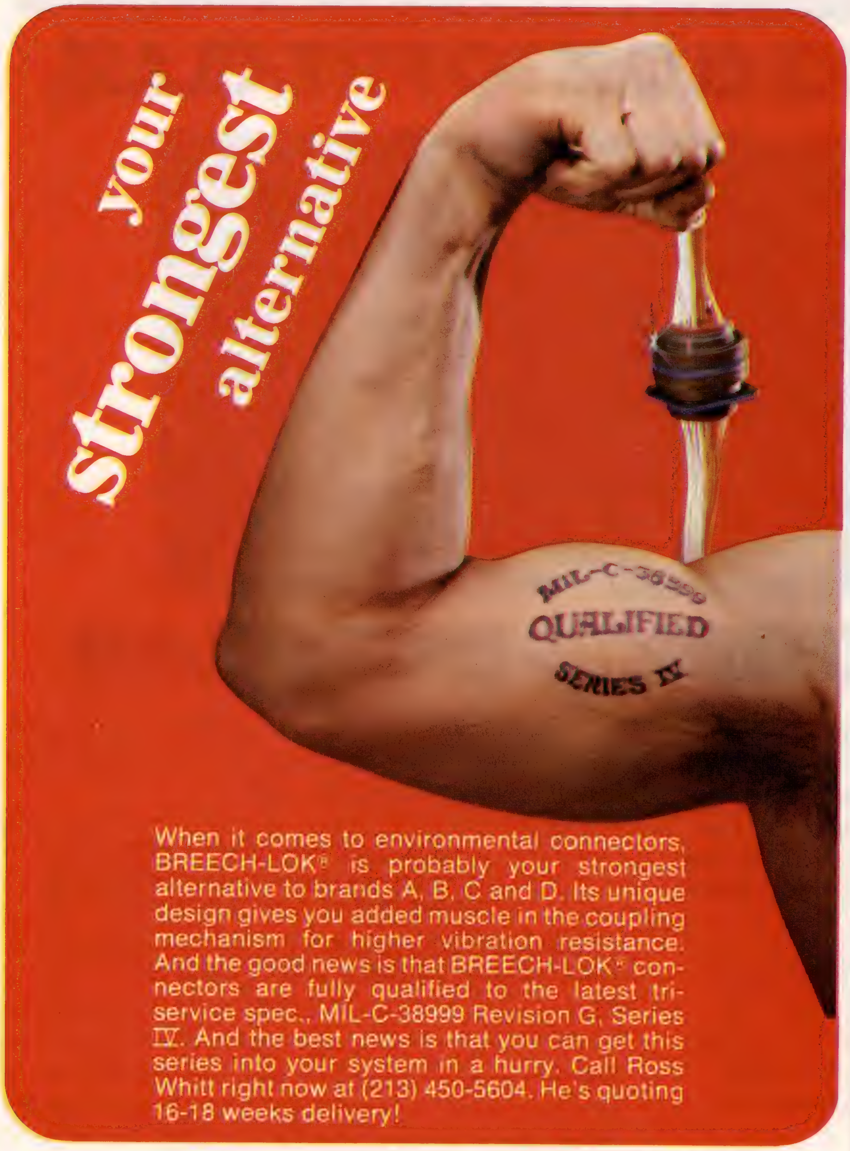
CIRCLE 360

High-level noise module covers 0.5 to 1 GHz

A high-level noise module, NOD45, covers a range of 500 to 1000 MHz. Minimum output is -82 dBm/$\sqrt{\text{Hz}}$ across a 50-Ω load. Peak factor is greater than +12 dB. The module stays stable over a 10 to 50-C range with a tempco of 0.01 dB/°C. Long-term drift, after warm-up, is less than 0.05 dB/25 h. The noise output is through an SMA connector while solder lugs are used for bias. The module's housing measures 9.9 × 4.4 × 1.5 in.

Micronetics, 36 Oak St., Norwood, NJ 07648. (201) 767-1320. 8 wks.

CIRCLE 361



When it comes to environmental connectors, BREECH-LOK® is probably your strongest alternative to brands A, B, C and D. Its unique design gives you added muscle in the coupling mechanism for higher vibration resistance. And the good news is that BREECH-LOK® connectors are fully qualified to the latest tri-service spec., MIL-C-38999 Revision G, Series IV. And the best news is that you can get this series into your system in a hurry. Call Ross Whitt right now at (213) 450-5604. He's quoting 16-18 weeks delivery!

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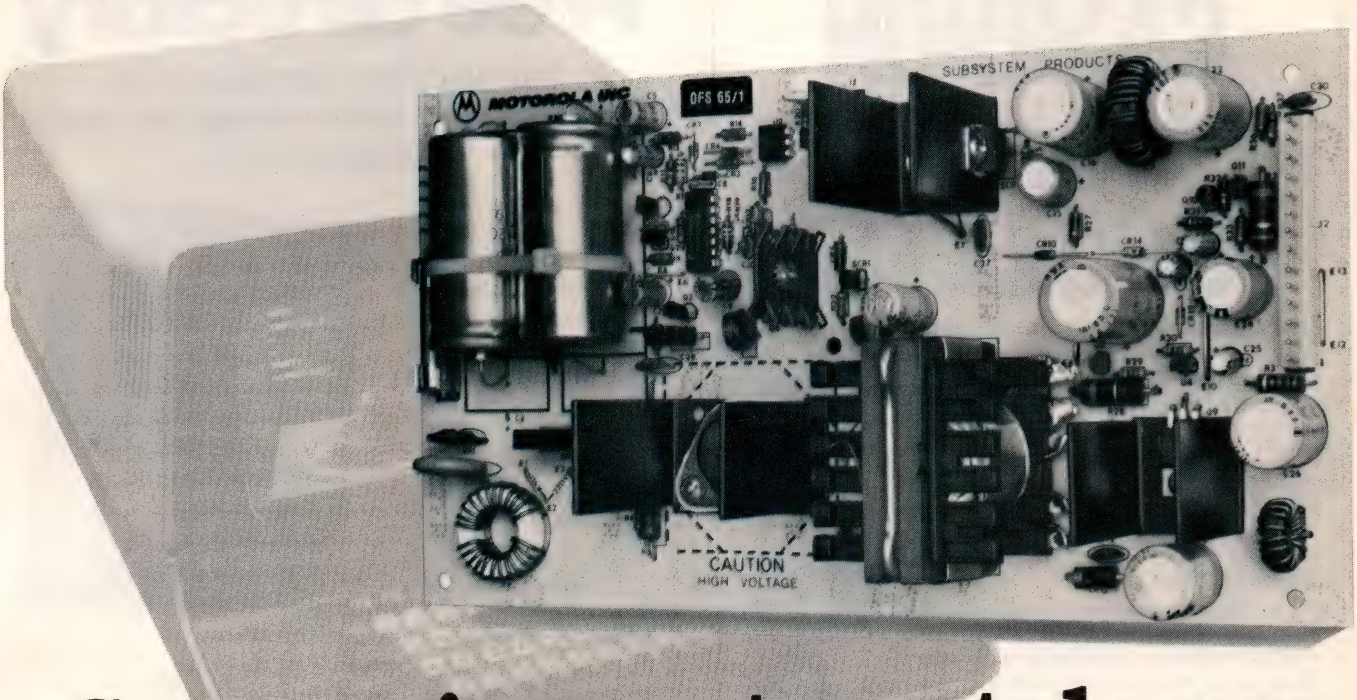
CIRCLE 109

Technological leadership.



Cut equipment cost down to size with our 65 W, multi-output, mini switcher.

Now you have a full-featured, switching power supply with all the quality and reliability of bigger, more expensive units without all the cost . . . Motorola's 50 W to 65 W, OFS65, open-frame switcher family for terminal, display, MPU and other low-power system applications.

Less parts, more MTBF.

Cooler and more efficient than equivalent linears, parts count is about 20% less than similar switcher types—also a key cost-reducing element. No fans are required for cooling the design which boasts about 2 W output per cubic inch. Efficiency for the triple-output unit is approximately 65%.

Full protection for self and system.

Small and lightweight (about 20 oz.), the OFS series is fully self-protected from abuse at output terminals. Shorts and opens can't damage it with high, low or in-between input voltages. Overload simply causes periodic recycling with normalcy restored when overload is gone.

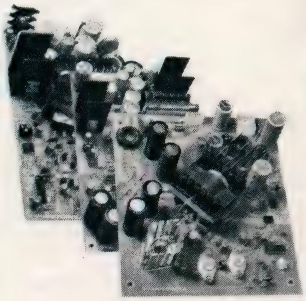
And if your system's going to crash due to power line failure, it sends a warning signal to the MPU to unload volatile memory with output voltage remaining within regulation for 32 ms after loss of nominal line voltage. That's about twice as long a spec as some others offer.

Of course, it provides EMI filter on input, soft start and reverse polarity protection.

Standard, 24-hour burn-in is included with reliability ensured through computer-aided, worst-case analysis and individual testing of every IC and discrete device.

Excellent line regulation of ±0.15% is provided on all outputs; load regulation is 1% on all positive outputs and 6% on the negative outputs.

Best of all, OFS published prices are down where they should be: $130, 100–249, with very competitive quantity pricing.



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Other sizes and performance ratings are available for individual needs.

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through silicon.

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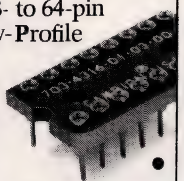
CAMBION V-L-P* IC SOCKETS

Now available in 2 different styles and in 8- to 64-pin positions, are Cambion's new, * Very-Low-Profile (.093") *Series 703-43XX* IC Sockets:



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Machined body provides rigidity for pin alignment and for IC insertion/extraction. Ask for evaluation samples and the new IC Socket Catalog! Cambridge Thermionic Corp., 445 Concord Avenue, Cambridge, MA 02238, Tel: (617) 491-5400, Telex: 92-1480, TWX: (710) 320-6399.

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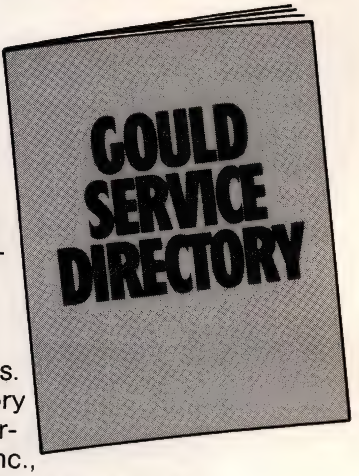
CIRCLE 116

Free directory

of service centers for Gould test and measurement instruments.



Call today for this fast reference to all 23 Gould service centers located across the U.S. and Canada. These service centers offer a variety of maintenance programs including fixed fee, time and materials or customer site contracts.

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CIRCLE 117

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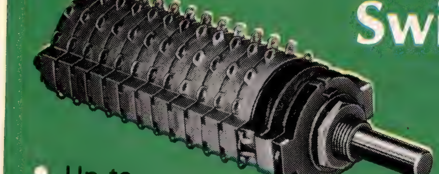

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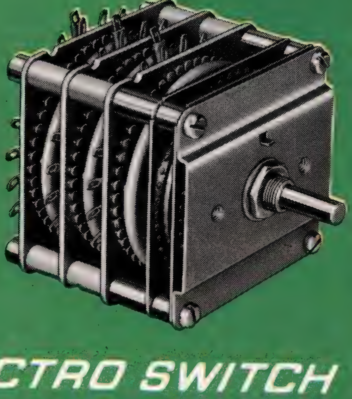

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CIRCLE 111

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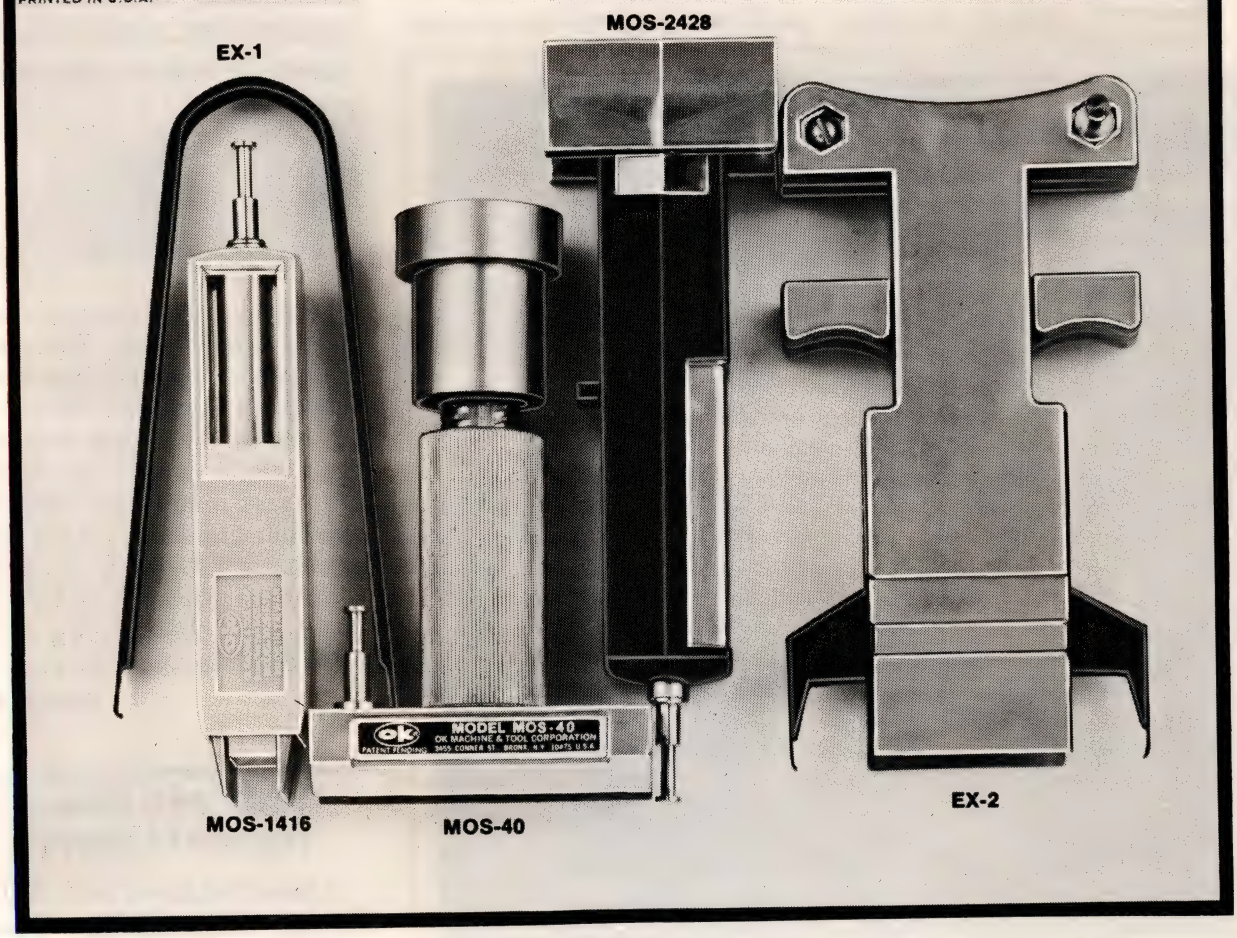
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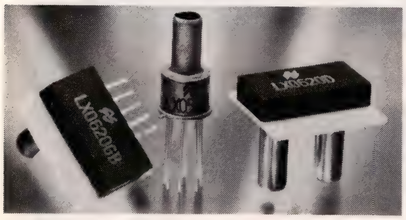
CIRCLE 113

Monolithic sensors operate to 100 lb/in.²

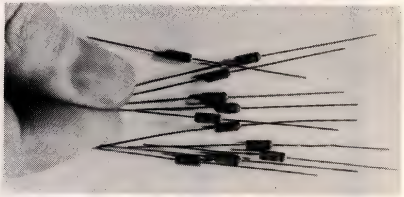


Monolithic pressure sensors, LX0520 and LX0620, operate at up to 100 lb/in.². Compatible working media include most non-corrosive gases, fuels, oils, refrigerants and hydraulic fluids. The devices are offered in absolute, differential and gauge pressure types. The 100 lb/in.² transducers are available in TO-5 metal cars or ceramic packages. Sensitivity is 0.2 to 0.8 mV/lb/in.². On-chip temperature compensation reduces typical span tempco to 0.02 mV/°C.

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 737-5000. Typical $30 to $36; stock to 6 wks.

CIRCLE 365

Avalanche zener diodes present low impedance



Low-voltage avalanche zener diodes exhibit sharp knees and present a low dynamic impedance of between 10 and 75 Ω, depending on voltage. The devices, available in a 2.8 to 10 V range, provide 400 mV power dissipation and a 1-V maximum forward voltage drop at 100 mA. DO-7 cases are used.

Compensated Devices, 166 Tremont St., Melrose, MA 02176. (617) 665-1071. stock to 2 wks.

CIRCLE 366

Power p-i-n diodes replace hf relays

A family of power p-i-n diodes, KS1001, 1002 and 1003, switches 1000 W of rf from 2 to 30 MHz. The diodes have carrier lifetimes of 6 μs and distortion more than 80 dB below the fundamental. The parts are designed for switching hf transmitters, antenna filters and matching networks. In most applications, the 1200-V devices can replace electro-mechanical relays. Series resistance is only 0.14 Ω at 750 mA of forward bias current. The diodes come in plastic packages.

KSW Electronics, S. Bedford St., Burlington, MA 01803. (617) 273-1730. $1.10 to $1.60 (100 qty); 8 to 9 wks.

CIRCLE 367

WHY STRUGGLE WITH CAGE ASSEMBLY?
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40 STANDARD CAGE AND MODULE COMBINATIONS
SPECIALS TO ORDER

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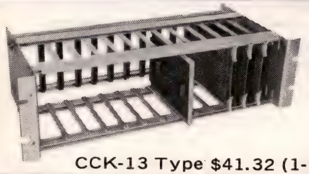
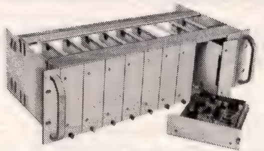
EFP MODULE CAGES

Discrete Card Guide Cages -- Aluminum or plastic. 4-way adjustable connector struts. 6 sizes off the shelf.

Cardmount Cage Assemblies -- Cards mount in 4 std. widths of L panels; 11 off-the-shelf cages; 13 module sizes.

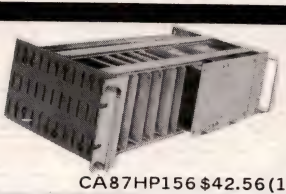


CCK-13 Type $41.32 (1-9)



CCM13 $99.55 (1-9)

CCK3 $39.62 (1-9)



CA87HP156 $42.56 (1-9)

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CIRCLE 114

Some people think the best feature of our Digibridges® is price. Others think performance.

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So take a look at the Digibridge family from GenRad. You'll find everything you want. At a price you can afford.

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1657 RLC Digibridge

Our 1657 Digibridge gives you everything you need for basic RLC testing at a modest $1500. It's accurate to 0.2%, and lets you test at 1 kHz as well as 120 or 100 Hz. The 1657 gives you continuous measurements at 3 per second and the choice of series or parallel measurement modes.

1658 RLC Digibridge

For more critical measurements, our 1658 gives you the measurement accuracy of 0.1% at 1 kHz and 120 or 100 Hz. Its features include automatic limit comparison capability and selectable test speeds for fast error free measurements. Range selection is automatic and the 1658 has external DC bias capability, too. All for just $3,200. As an option an IEEE bus/handler package for data communication and high speed automated testing is available.

1687 1 MHz LC Digibridge

In a 1 MHz tester our 1687 gives you 0.1% accuracy on C measurements, 0.2% accuracy on L measurements. You get most of the features of our 1658: automatic range selection, selectable measurement speeds, automatic limit comparison capability, external DC bias capability, and more. Like self-check diagnostics. At a cost of just $4000. Optionally, you can also get an IEEE bus/handler interface, external fixturing and a 1.0V rms test voltage.

1688 Precision LC Digibridge

Our top of the line 1688 provides basic accuracy of 0.02%, a choice of 254 frequencies from 240 Hz to 20 kHz, and a 1 PPM D measurement resolution. Test speeds can be set at .5, 1.5, 3.0 or 7.0 measurements per second and test voltages at .25V or 1.0V. Of course range selection, limit comparison capability and self-check diagnostics are also included. And that's the most performance you can buy for $4900.

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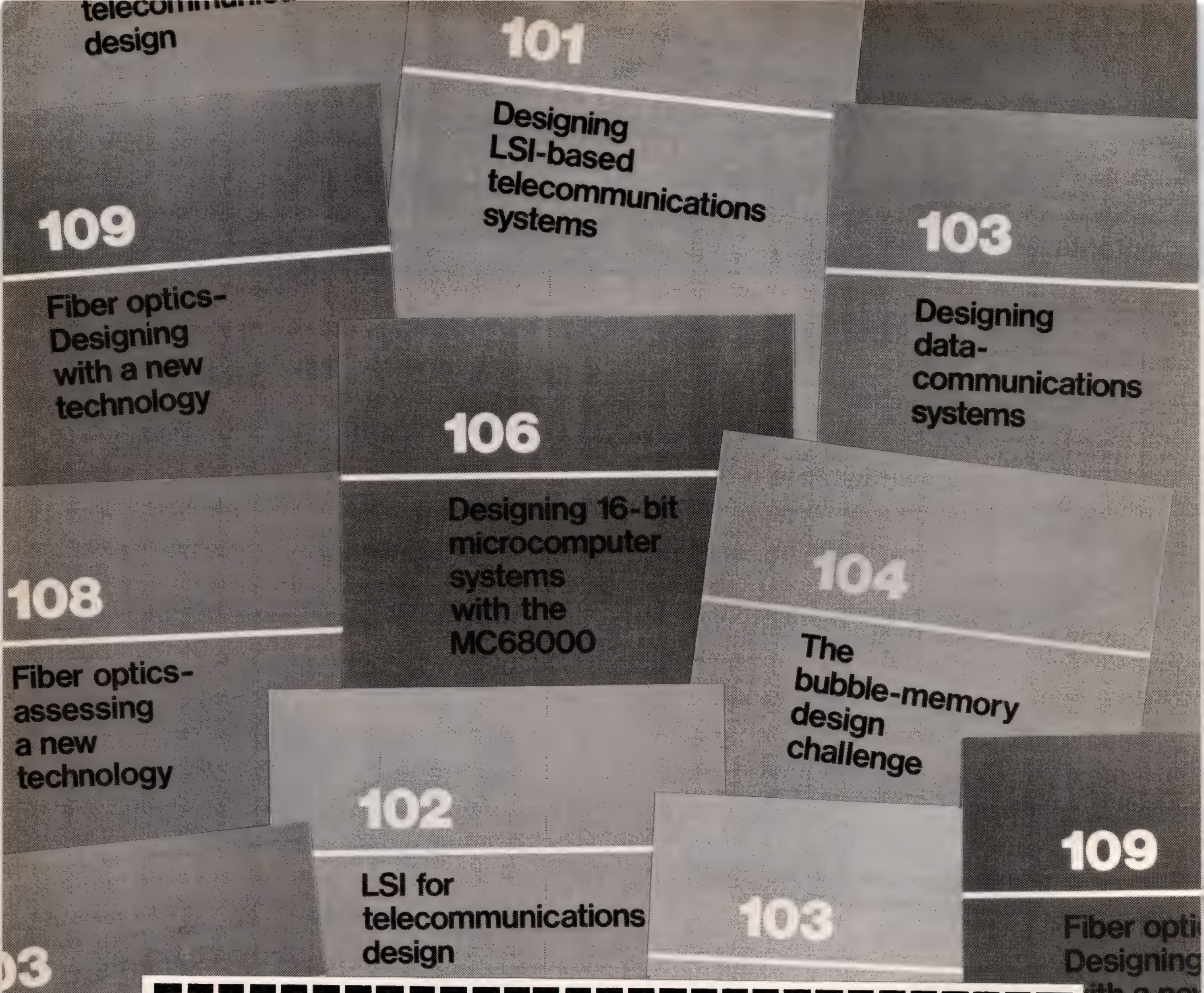
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109
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103
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106
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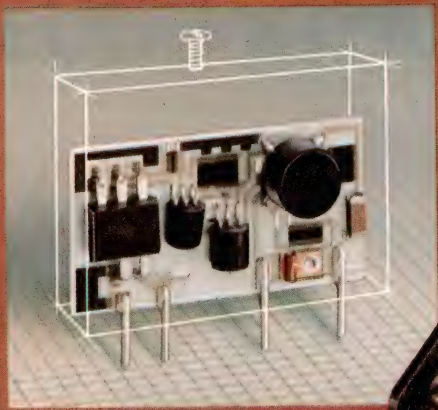

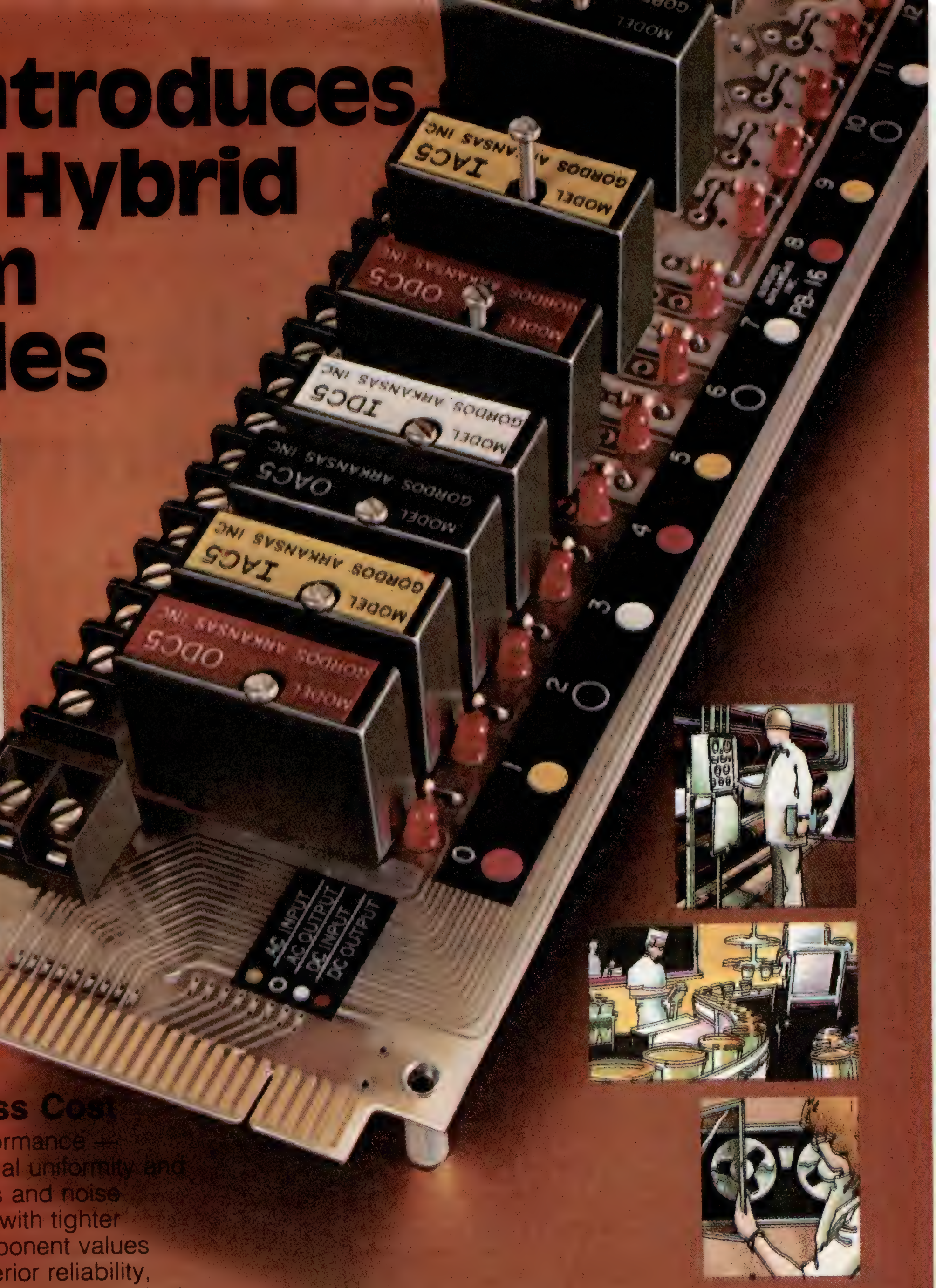

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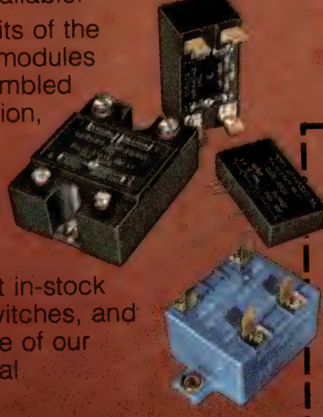

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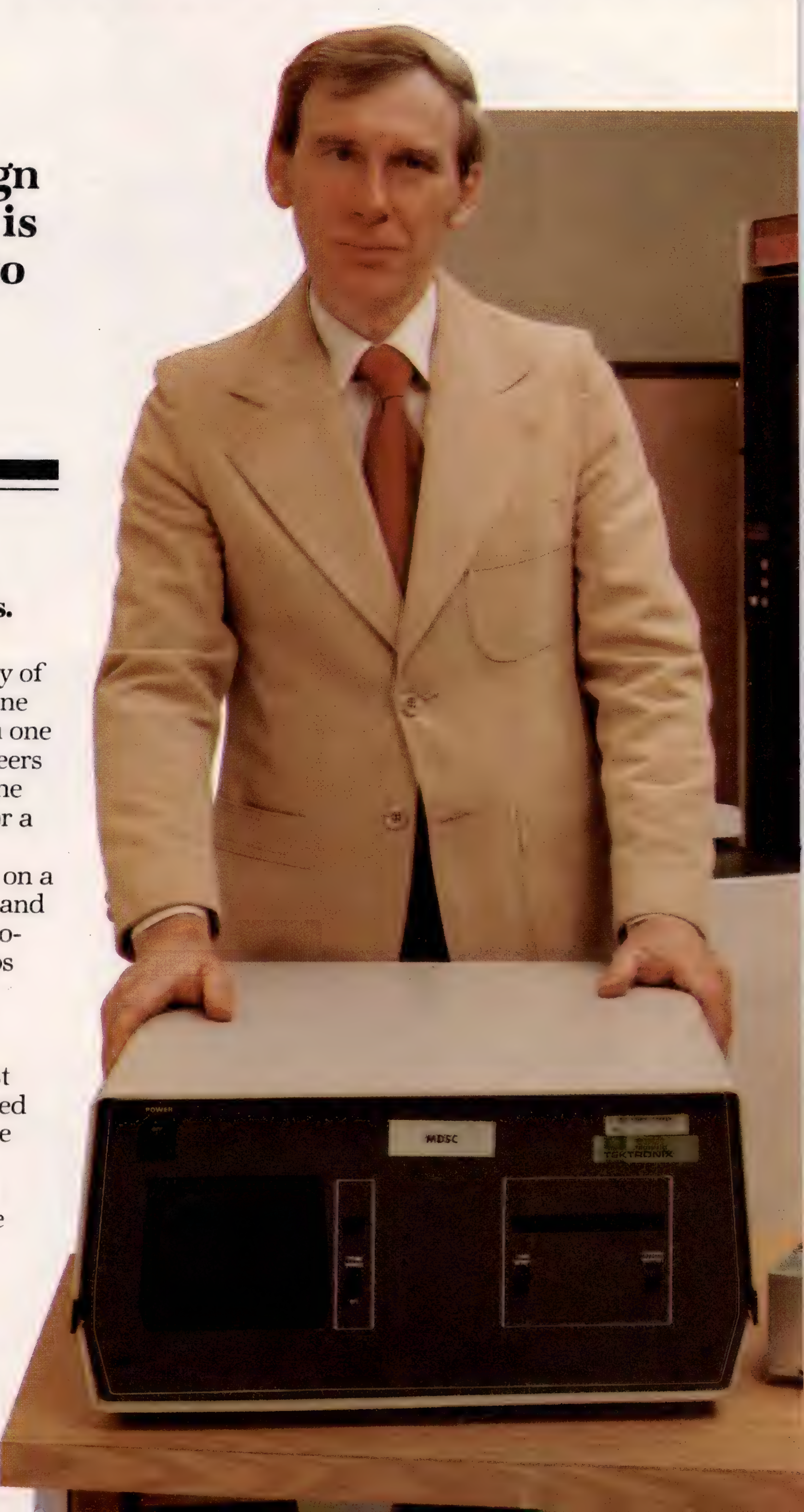
The Microprocessor Design Support Center (MDSC) is Boeing's innovative answer to large scale microprocessor development. Tektronix makes it possible.



Boeing now supports over 120 engineers working on 35 projects.

Before the creation of the MDSC, Boeing used a variety of different vendors' stand-alone development systems. Each one supported only three engineers at a time, and more than one system was often needed for a single project.

Now, software is developed on a DEC PDP 11/70® computer and transferred to six 8001 Microprocessor Development Labs for in-circuit emulation, debugging, and prototype integration.

By using one multi-user host computer with six distributed 8001s, Boeing is able to more efficiently support 120 engineers. With 8001s costing half as much as stand-alone development systems.

couldn't do what six are doing.

Development isn't limited by dedicated, single-vendor systems.

The 8001 supports every microprocessor Boeing uses, so, they're free to choose the right microprocessor for the job. And whether it's the Texas Instruments TMS9900, Zilog Z80A, Intel 8048, Motorola 6800, RCA 1802, or 14 others — the 8001 emulates it. Tek's multi-vendor support doesn't lock Boeing into one vendor's family of microprocessors.

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When every engineer uses the same equipment and the same operating system for every project, it translates into a faster learning curve. And a more efficient, flexible team. For Boeing — or for you.

The world over, Tektronix supports your team with our team, assisting you with everything from development system configuration planning to training to service. Whether your development plans include our 8001 MDL, or our stand-alone 8002A MDL, we'll back you with quality — every step of the way. For a closer look at Boeing's innovative use of the 8001, please call your local Tektronix Field Office or write to us for our Boeing Application Note.

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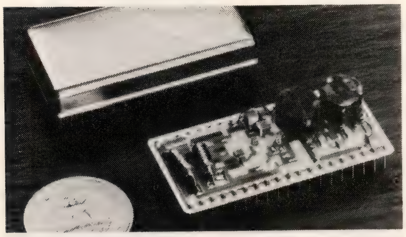
CIRCLE 121

Dc/dc converters put out up to 4 W

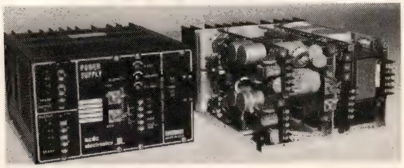


M-Series μ-Power dc/dc converters put out up to 4 W over a −55 to +85 C range. The 38-pin metal package measures only 1 × 2 × 0.3 in. Inputs of 12, 24, 28 or 48 V dc provide isolated, dual-tracking outputs of ±12 or ±15 V dc. Full short-circuit protection is provided through fold-back current limiting.

Integrated Circuits, 13256 Northrup Way, Bellevue, WA 98005. (206) 747-8556.

CIRCLE 371

Triple-output switchers supply 300 W



Three additions to the RS/RT line of switching power supplies provide triple outputs for a total power of 300 W. The units offer isolated auxiliary outputs. The input, nominally set at 115/230 V ac, can be internally changed for 180 to 264 V ac. Standard versions meet VDE0875 requirements for EMI. As an option, the supplies will meet the input isolation requirements of VDE0804. RT305 offers 5 V at 60 A, 15 V at 4 A and 12 V at 5 A; RT306, 5 V at 60 A, 24 V at 2 A and 12 V at 5 A; RT307, 5 V at 60 A, 24 V at 2 A and 15 V at 4 A.

ACDC Electronics, 401 Jones Rd., Oceanside, CA 92054. (714) 757-1880. $550; stock.

CIRCLE 372

Dual-output clock reduces parts count

A compact, dual-output clock oscillator saves board space by providing multiple frequencies from a single device. The oscillator, sealed in a resistance-welded miniature DIP, provides simultaneous output of two separate frequencies ranging from 250 kHz to 25 MHz. The second frequency is normally a multiple of 2, 4, 8 or 16 of the first. A TTL output is supplied with rise and fall times of less than 10 ns. Up to 10 TTL gates can be driven using an input voltage of 5 V dc.

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CIRCLE 373

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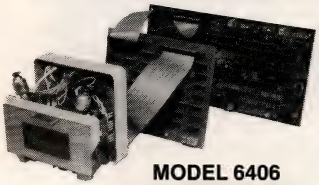

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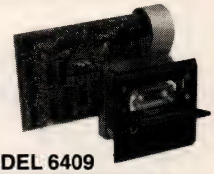

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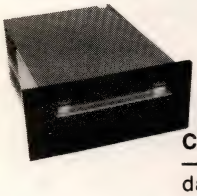

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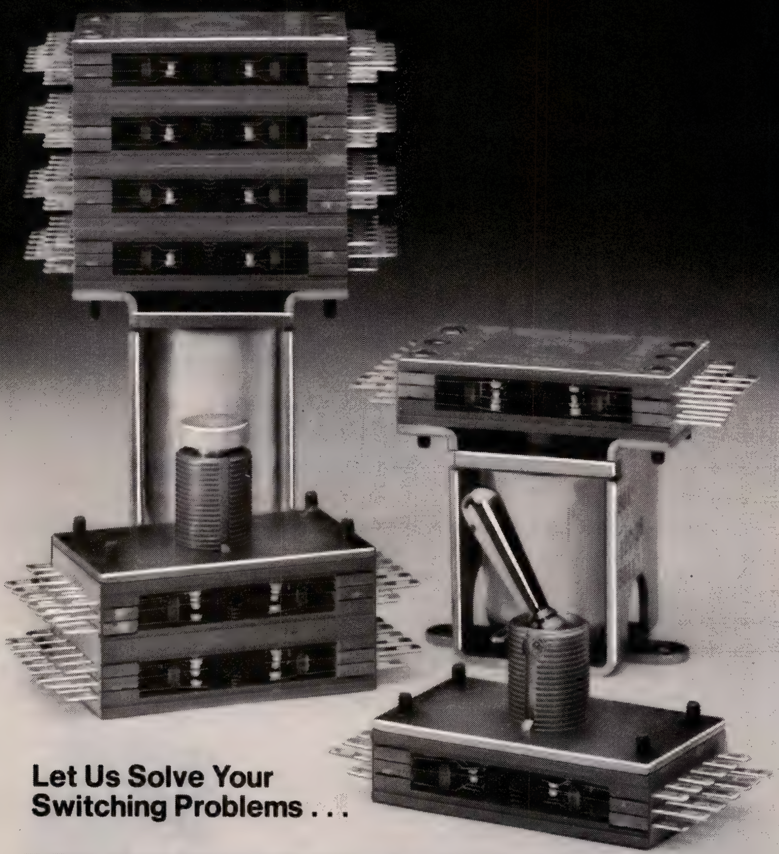

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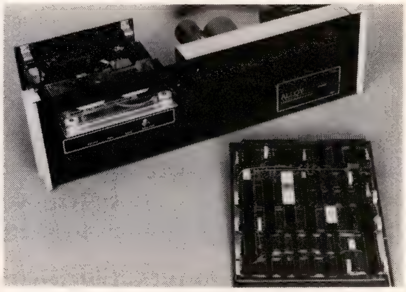
CIRCLE 123

Dual cart system backs up Winchester



A dual cartridge tape subsystem, DMN-1, provides backup data storage for Winchester drives. The DMN-1 also suits tape spooling and other mass storage requirements. Fully supported under DOS and IRIS, the unit emulates the NOVA 4030 series magnetic tape system. DMA transfer rate is 20-k/s. Only 5-1/4 in. of vertical mounting space is required.

Alloy Engineering, 85 Speen St., Framingham, MA 01701. (617) 620-1710. $2600 (25 qty).

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Shugart Technology, 340 El Pueblo Rd., Scotts Valley, CA 95066. (408) 438-6550. $1500.

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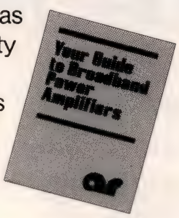

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Design Aids

Gas-plasma displays

Comparison specifications of Self-Scan single row gas-plasma displays are outlined in a four-page guide. Burroughs OEM Marketing. **CIRCLE 376**

Electronic hardware

A laminated 8-1/2 × 11-in. reference chart describes electronic hardware. R.A.F. Electronic Hardware. **CIRCLE 377**

Templates

A designers/engineers template makes designing pneumatic circuits easier, using the simplified air logic symbols system. Clippard Instrument Laboratory. **CIRCLE 378**

Epoxy resins

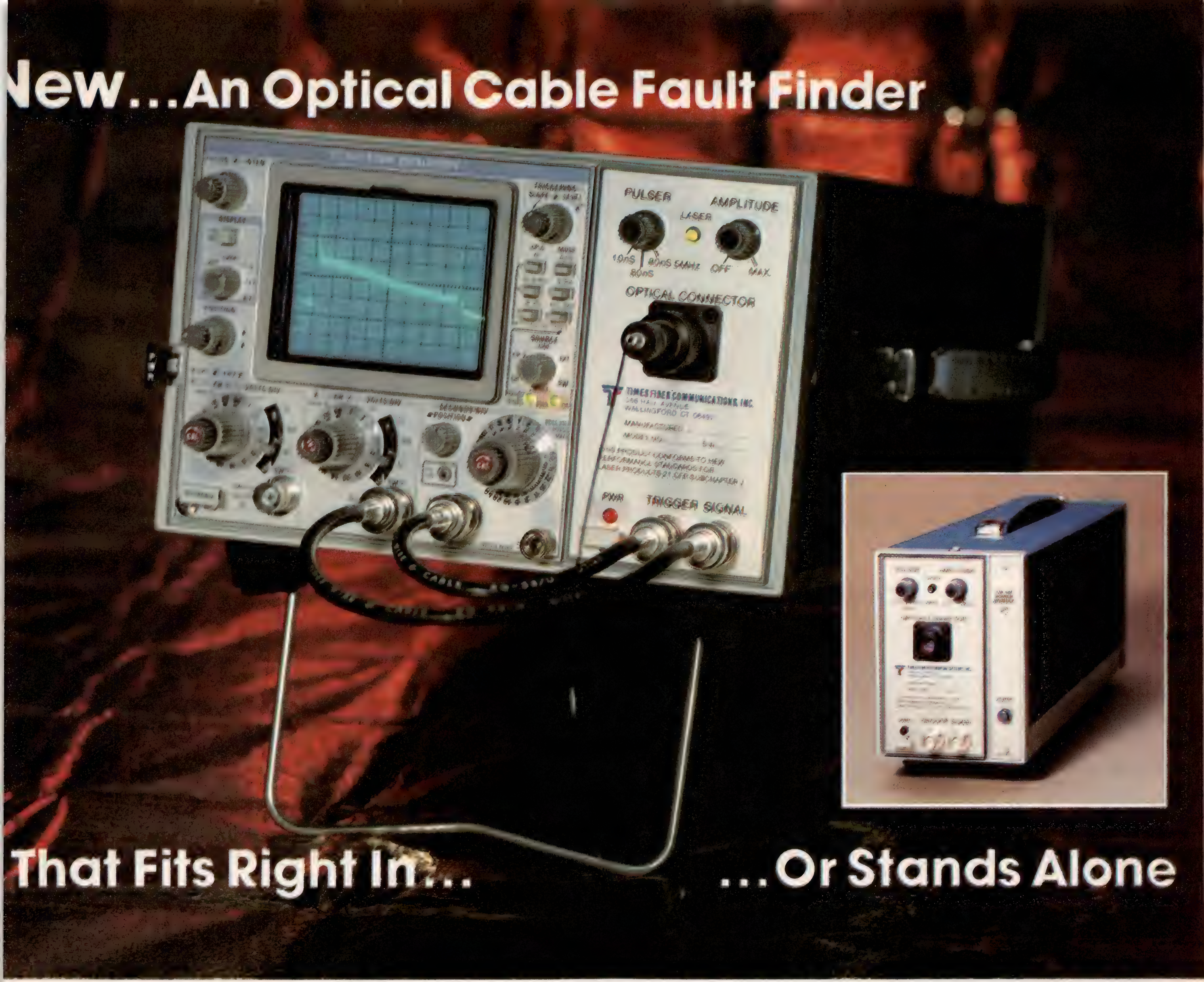
A two-page electronic-grade epoxy-resin selector chart describes one or two-component systems and principal characteristics. A cure guide and a temperature use guide are included. Acme Chemicals & Insulation. **CIRCLE 379**

Recorders

The Recorder Book, an eight-page guide, assists users in the selection of circular-chart, strip-chart, multipoint and direct-sensor recorders. Honeywell Process Control. **CIRCLE 380**

Temp conversion chart

How to determine °F or °C equivalents for a wide range of temperatures is shown in a conversion chart. Associated Environmental Systems. **CIRCLE 381**



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CIRCLE 126

ROUND TRIP 8-BIT B

OUR NEW 8-BIT ADC'S AND DAC'S GIVE YOU A GREAT ONE-WAY OR ROUND-TRIP PACKAGE, AT A PRICE THAT'S UNBELIEVABLE.

Now you can get in and out of your μP for the lowest fares in town.

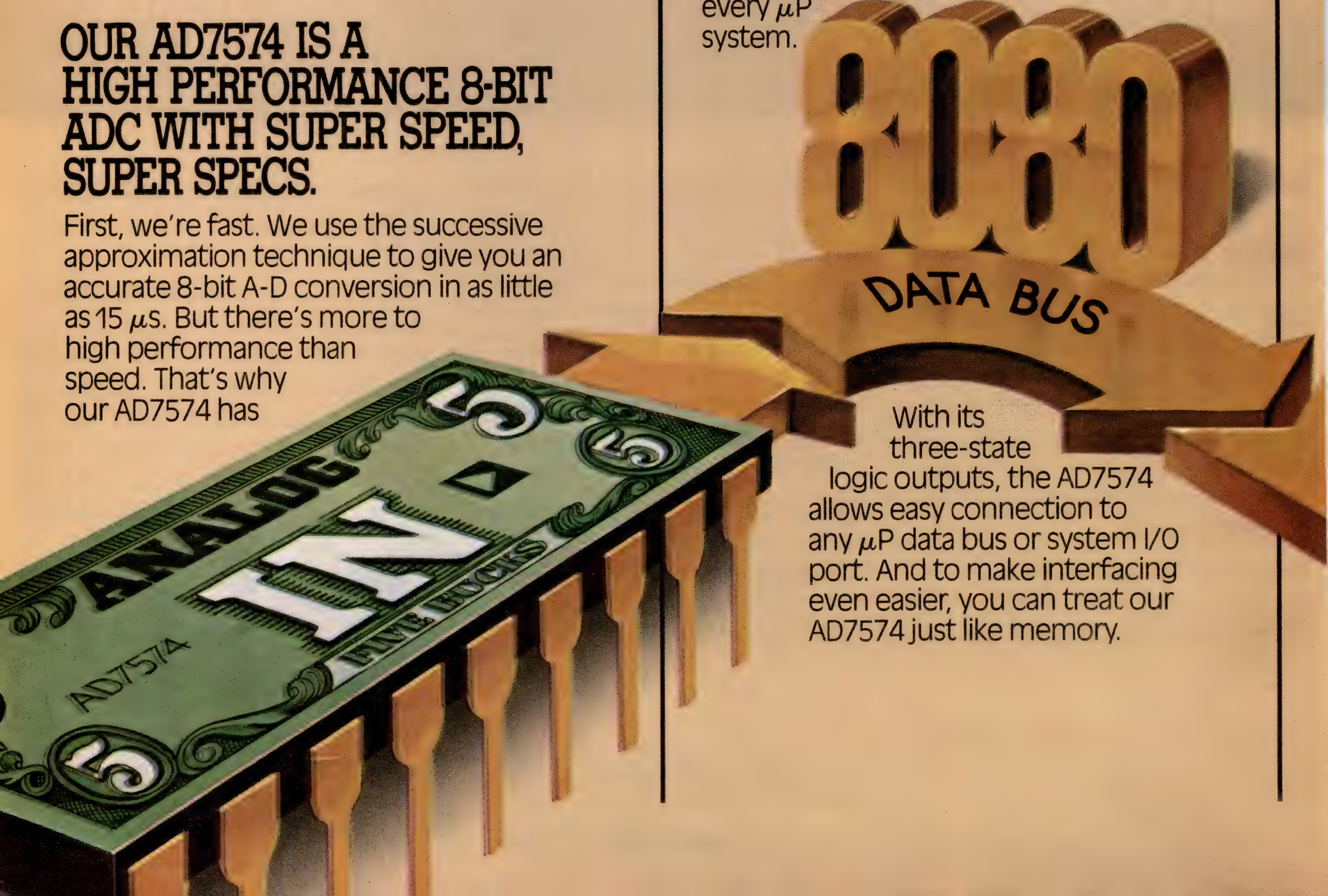
Our AD7574 comes as low as $5 in 1000's, and offers specs and features you expect only from more expensive hybrids. Our AD7524 is priced even lower – $3 in 1000's. Take them together and you've got a complete, reliable A-D/D-A μP interface for only $8.

OUR AD7574 IS A HIGH PERFORMANCE 8-BIT ADC WITH SUPER SPEED, SUPER SPECS.

First, we're fast. We use the successive approximation technique to give you an accurate 8-bit A-D conversion in as little as 15 μs. But there's more to high performance than speed. That's why our AD7574 has its own internal comparator so you never have to fiddle with external components to get full 8-bit transfer accuracy. And our internal clock oscillator runs only during conversion for minimal power dissipation. In addition, the AD7574's small 18-pin DIP size, monolithic reliability, +5V supply, and the low power consumption inherent in CMOS make it perfect for applications in avionics, instrumentation and process automation.

DIRECT INTERFACE TO μP.

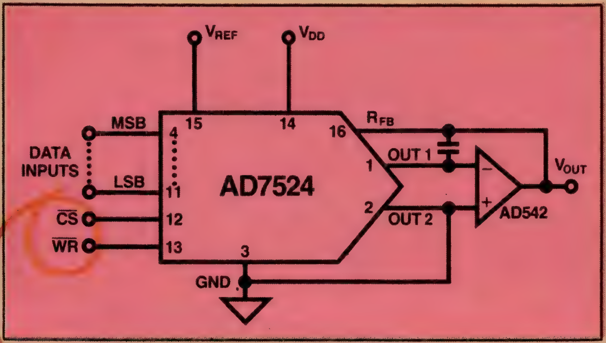
Our AD7574 has great handshaking ability for quick and easy μP interfacing. And all conversion operations are controlled by just two input signals, $\overline{CS}$ and $\overline{RD}$, available in every μP system.



With its three-state logic outputs, the AD7574 allows easy connection to any μP data bus or system I/O port. And to make interfacing even easier, you can treat our AD7574 just like memory.

US FARES. $8. WOW!

OUR AD7524 IS AN 8-BIT DAC WITH LATCHES, AND ACCURACY TO ±1/8 LSB.



DIRECT CONNECTIONS TO YOUR µP's CONTROL BUS!

We've taken one of our high performance 8-bit multiplying digital-to-analog converters and added level triggered latches – with on-chip control logic for extended interfacing capabilities. So our new AD7524 can be easily connected to nearly all 8-bit µP's, as well as I/O ports that provide latched data, without the need for supplementary circuitry.

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Bus in with our AD7574. Bus out with our AD7524. Or go round-trip with both. No matter which way you go, you won't find better fares than Analog's. To get all the facts on these two exciting new full performance µP-compatible converters, call Doug Grant or Don Travers at (617) 935-5565. Or write
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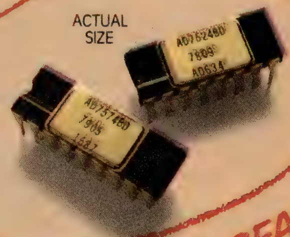
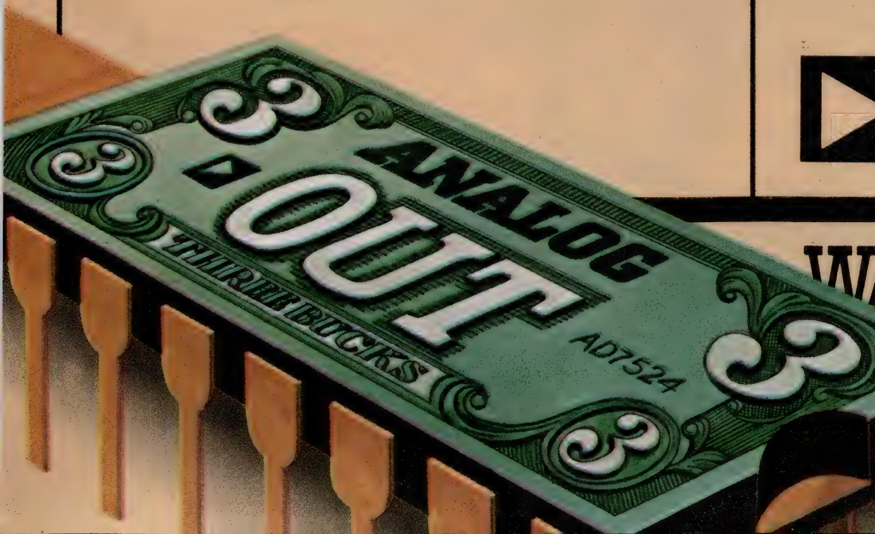


WE'VE GOT 'EM BEAT COMING AND GOING!



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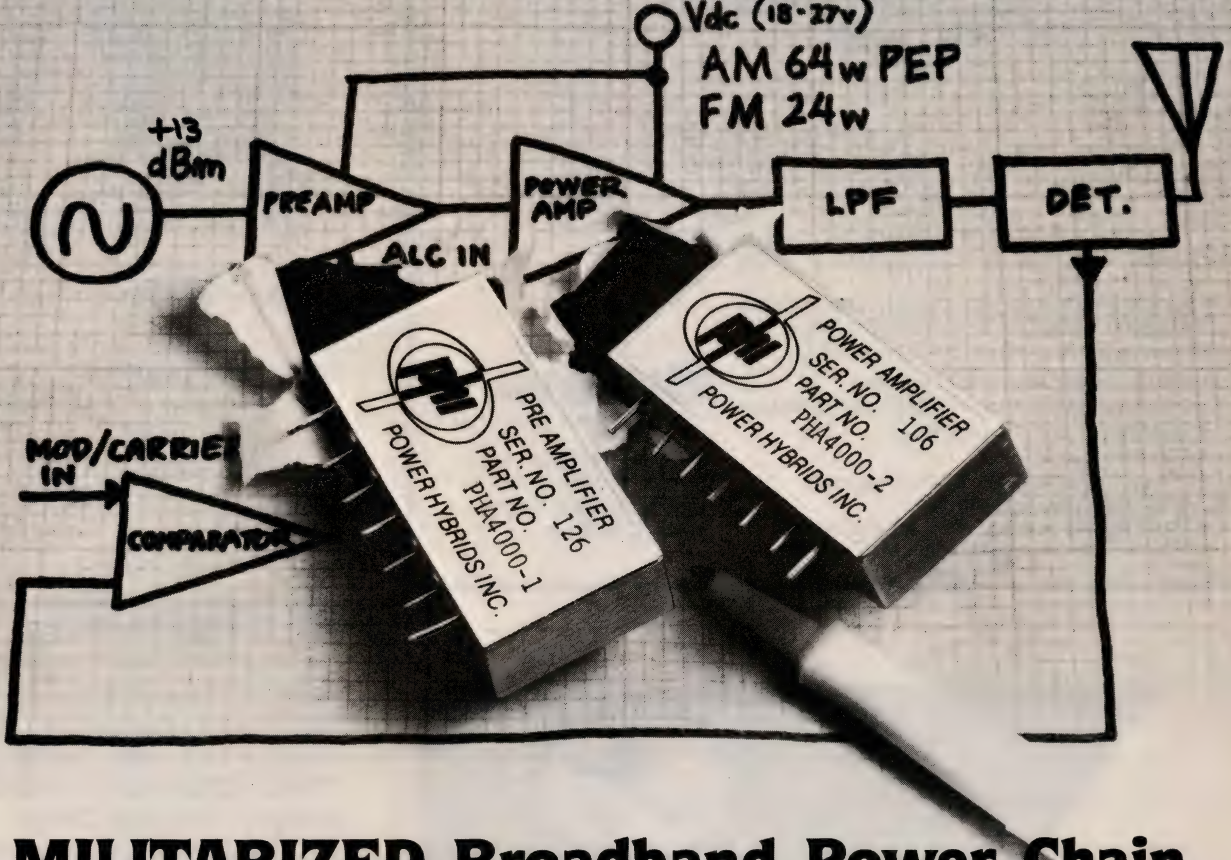

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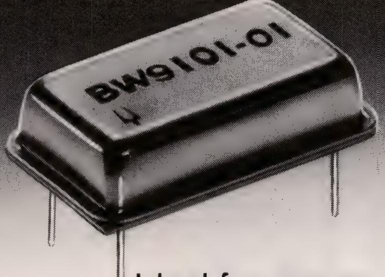
CIRCLE 131

Low cost crystal clock oscillators for timing sources



Ideal for use as
clock generators and timing sources
where size, cost, performance
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- Hybrid circuit packaging techniques provide excellent reliability at competitive prices.
- Frequency range from 250KHz to 40 MHz
- Seated height only 0.200 inches
- Occupies only 0.815"×0.515" on PC board
- Operated from +5 volt supply
- TTL compatible
- Frequency stability ±0.01% over their specified operating range
- Hermetically sealed, 100% leak tested to MIL-STD 883A and solvent resistant.

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CIRCLE 132

For years, our 75 MHz Model 4171F has been the classic move to make in monolithic crystal filters. This royal 4-pole creates a ±13 kHz 6 dB bandwidth in a single HC-18 envelope. It puts a stunning checkmate on noise. And best of all, it doesn't take a king's ransom to put it on your side of the board.

The standard in monolithic crystal filters.

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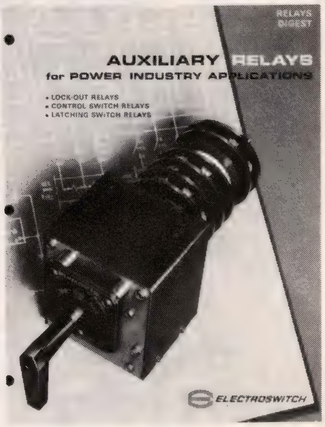
New Literature



Auxiliary relays

Auxiliary relays for power industry applications are featured in a four-page digest. Data on laboratory testing to IEEE-STD-323-1974 and IEE-STD-344-1975 are included. Electro Switch. **CIRCLE 382**

Data storage interfaces

Features of quad size disk and magnetic tape controllers and couplers available for DEC LSI-11, 11/2 and 11/23 and PDP-11 CPUs are covered in a four-page brochure. Dilog.

CIRCLE 383

Test equipment

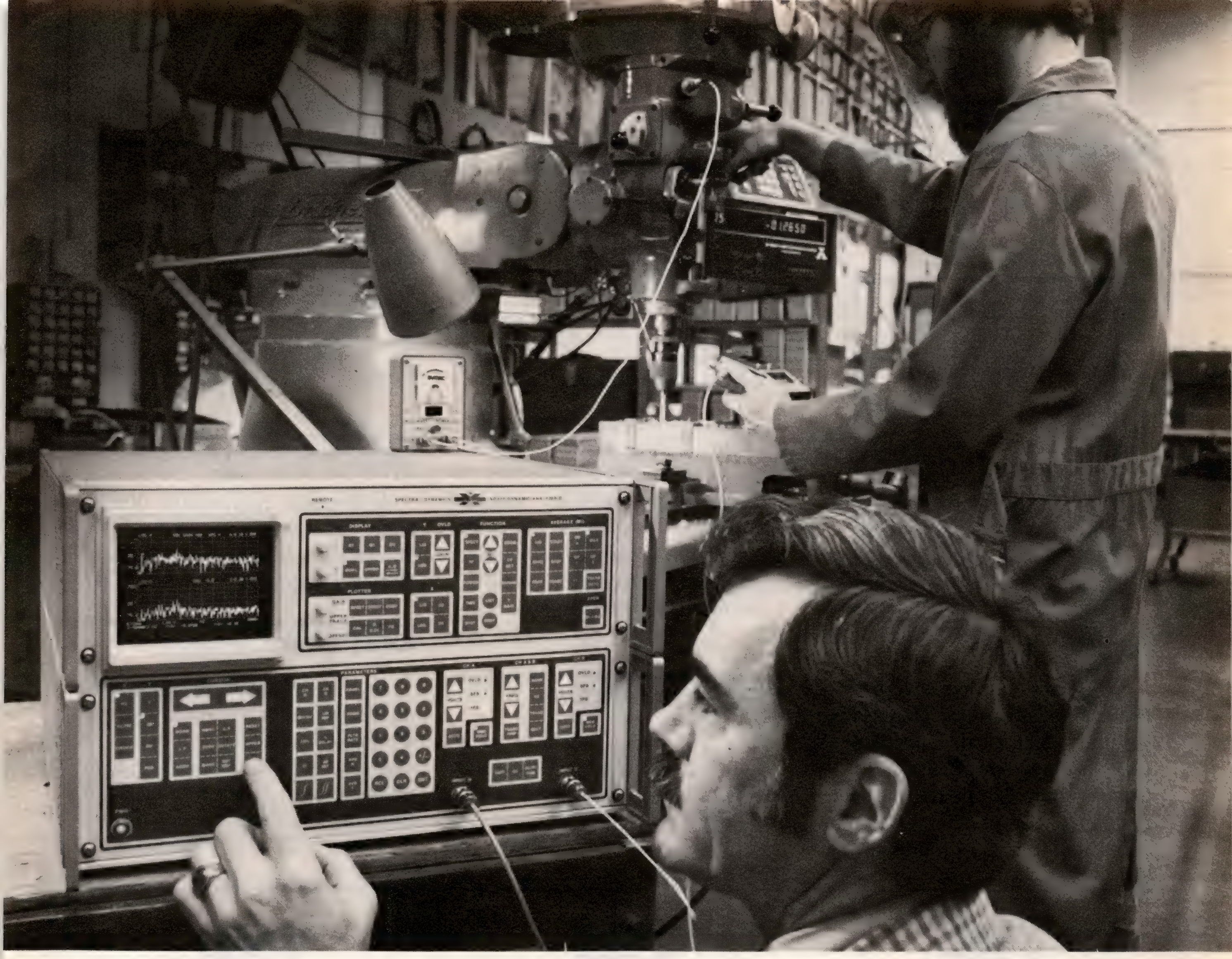
The 1980 Philips Test & Measuring Instruments catalog contains complete information on electronic test equipment. Philips Test & Measuring Instruments.

CIRCLE 384

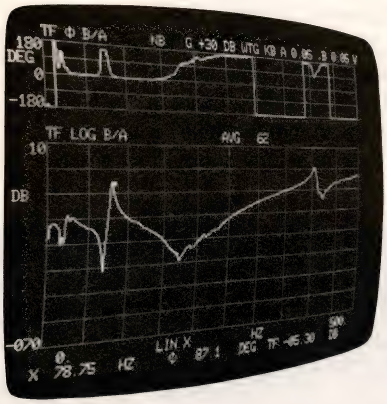
Circuit breakers

A 20-page brochure features the APL/UPL electromagnetic circuit breakers. Master drawings and diagrams show the application of these circuit breakers. The brochure contains charts, typical delay curves and mounting details and dimensions. Airpax

CIRCLE 385



Introducing the SD375. The two-channel analyzer that's easy to operate . . . and easy to buy.



The SD375 isn't the first two-channel signal processor on the market. Just the smartest. And the most versatile and easiest to set up and operate. And, above all, more features and capabilities per dollar — $19,600 base U.S. price — than any other two-channel analyzer on the market.

It tells you everything you want to know about signals and their cross properties . . . *instantly.* Full annotation is the key. The SD375 shows clearly every parameter and scaling factor of the test . . . where the test is at every moment . . . and (after the test) instantly readable results. No guesswork, no mysterious codes, no tricky conversions to be made.

Results are what you need, and fully processed results are what you get on a crystal-clear raster scan display. Readouts are available either in absolute values or calibrated and displayed directly in full engineering units — e.g. mils, g's, mechanical impedance, dynamic stiffness (or even furlongs per fortnight, if that's what you want).

The SD375's display conforms to the way you're used to seeing graphed information; you don't have to learn new ways of reading and interpreting a CRT to get the test results you need . . . *immediately.*

Plug-in options such as digital zoom and IEEE 488/RS-232 digital I/O add to the ease of using the new SD375. The digital I/O option permits *direct* connection to a variety of both TEK and H-P digital plotters . . . today's most widely owned, established display peripherals. The same digital I/O plug-in also provides unusually broad capabilities for remote control and sensing and computer processing of analytical data.

If you have two signals and have to know . . . *fast* . . . what's in them and how they inter-relate, find out about the new SD375. Call Roger Koch at (714) 268-7129. Or write to us.

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Spectral Dynamics
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CIRCLE 134

New Literature

Thyristor/diodes

A 60-page catalog covers thyristor/diode modules. The catalog includes electrical, mechanical and thermal specifications; diagrams and 37 pages of performance curves. Semikron International. **CIRCLE 386**

Temperature indicators

Temperature indicating thermometer strips, record indicators, clock indicators and paints are covered in a catalog. B H Frank. **CIRCLE 387**

HV power supplies

The EG series solid-state, high-voltage supplies are covered in a data sheet. The data sheet lists 10 models with output voltage ranges from 5 kV at 6 mA to 60 kV at 0.5 mA with fixed positive or negative, or reversible polarity. Glassman High Voltage. **CIRCLE 388**

Electrostatic systems

Descriptions, schematics and prices of electrostatic systems and components are contained in a 24-page catalog. Chapman. **CIRCLE 389**

Instruments

Products ranging from assembled instruments available in two weeks to products which can be calibrated and fitted to suit specific customer needs and delivered within four weeks are covered in catalog. The Foxboro Co. **CIRCLE 390**

Suppression filters

A 24-page engineering handbook features 16 types of RFI/EMI suppression filters. Power Dynamics. **CIRCLE 391**

Gunn devices

Applications and performance of the GC5700 and GC5800 series 5% and 6% efficiency high power negative-bias and positive-bias plated heat-sink Gunn devices are described in a bulletin. Frequency Sources, GHZ Div. **CIRCLE 392**

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THE SOLUTION:

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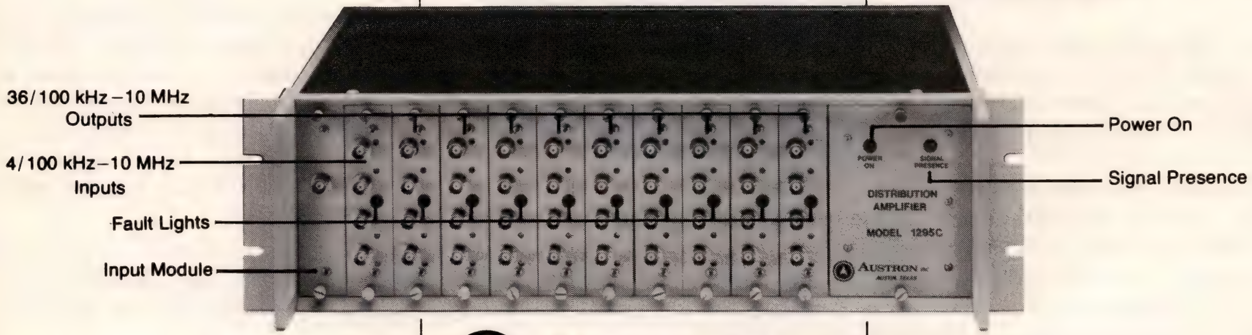

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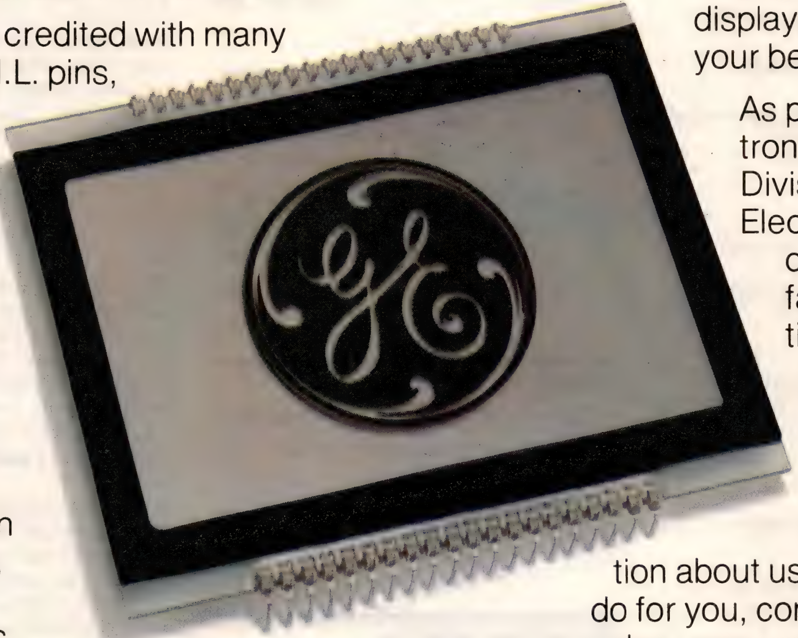
For additional information, contact Austron Time and Frequency Division.

CIRCLE 135

General Electric, the new name in LCD's.

The business you've known as Liquid Xtal Displays has a new name. A new name because last September, LXD became a part of the General Electric Company.



As LXD, we were credited with many industry firsts, D.I.L. pins, integral back lighting and dot matrix displays were among them. Our R&D activities produced materials which expanded the operating range and established new performance levels in the industry. Now, with the added resources of GE's Corporate Research and Development Laboratory, we'll be able to provide you with the most advanced technologies available. And they will be tested and proven reliable, in the General Electric tradition.

Today, our production facilities are three times what they were just six months ago.

So General Electric's Liquid Xtal Displays Operation (as we're now known) is your best source of "off the shelf" standard displays or custom displays. That's right, your best source.

As part of the Electronics Components Division at General Electric, we, like other component manufacturing operations, within GE, are geared to supply products to a wide variety of manufacturers.

For more information about us, and what we can do for you, contact your local sales representative, or write: General Electric Company, Liquid Xtal Displays Operation, 24500 Highpoint Road, Cleveland, Ohio 44122. (216) 831-8100. Telex 98-5442. In Europe, A.B. Gosta Backstrom (Stockholm, Sweden) Data Modul (Munich, W. Germany) or Norbain Optoelectronics (Reading Berkshire, England).

GENERAL ELECTRIC

CIRCLE 136

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Eastern Regional Sales Manager
Robert W. Gascoigne, Andrew Meehan,
Constance McKinley, Becky McAdams,
Roberta Renard, Stan Tessler,
Diana Andress, Carol Helton
Sales Assistants: Deborah DiPilla,
Francine Guerra, Dale Siegel,
Betsy Tapp
50 Essex St.
(201) 843-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)

Philadelphia
Thomas P. Barth (201) 843-0550

Boston
M. E. "Casey" McKibben, Jr.
113 River St.
Waltham, MA 02154
(617) 893-4441

Chicago 60611
Thomas P. Kavooras, Craig L. Pitcher
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200 East Ontario
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Cleveland
Thomas P. Kavooras (312) 337-0588

Texas
Craig L. Pitcher (312) 337-0588

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1307 South Mary, Suite 212
Sunnyvale, CA 94087
(408) 736-6667

United Kingdom-Scandinavia
Constance McKinley (201) 843-0550

Germany: Annemarie McCalla
50 Essex St.
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(201) 843-0550

Belgium, Holland, Switzerland
W.J.M. Sanders
S.I.P.A.S.
Raadhuisstraat 24 - P.O. Box 25
1484 EN Graft-de-Ryp, Holland
Tel: 02997-1303 and 3660
Telex: 13039 SIPAS NL
Telegrams: SIPAS-Amsterdam

France: Annick Wolff
Promotion Presse Internationale
7 ter Cour des Petites Ecuries
75010 Paris, France
Telephone: 247-12-05

Italy: Robert M. Saidel
Technimedia International
Piazzale Cadorna 4
20123 Milan, Italy
Tel: 80-1646
Telex: 25897 Utidioma

Tokyo: Haruki Hirayama
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ABP BPA

New Literature

Thumbwheel switches

Two data sheets cover three thumbwheel switches, the 43000 Miniswitch and the 44000/45000 Slimswitches. Specifications and engineering drawings are included. The Digitran Co.

CIRCLE 393

DIP sockets

A 28-page catalog covers DIP sockets, DIP headers, DIP jumpers, DIP programming devices and related DIP products. Dimensional data and specifications are included. Aries Electronics.

CIRCLE 394

Servo accelerometers

Specifications and applications of force balance servo accelerometers and inclinometers are described in a 12-page catalog. Columbia Research Laboratories.

CIRCLE 395

RFI shielded cases

RFI shielded cases, rf transfer switches and accessories are described in an eight-page catalog. Photos and drawings are included. Compac.

CIRCLE 396

Polyether polyols

A 40-page booklet describes a wide range of intermediates for rigid urethane foam. The booklet discusses typical properties and charts the effect of temperature on viscosity. Union Carbide.

CIRCLE 397

Pressure sensitive tape

Characteristics and applications of pressure sensitive tapes made with polyparabonic acid film are given in a two-page data sheet. CHR Industries.

CIRCLE 398

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- To provide a central source of timely electronics information.
- To promote communication among members of the electronics engineering community.

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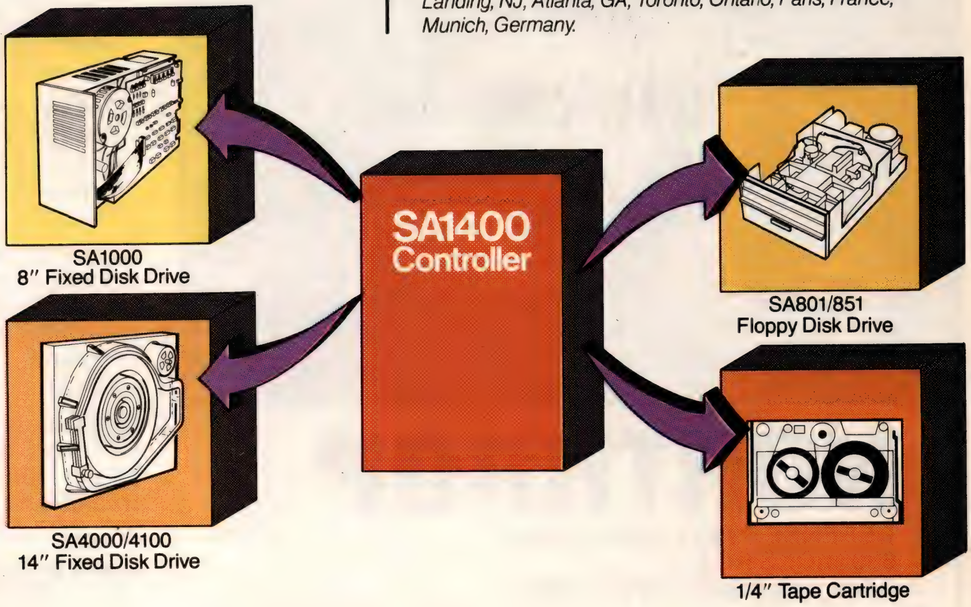

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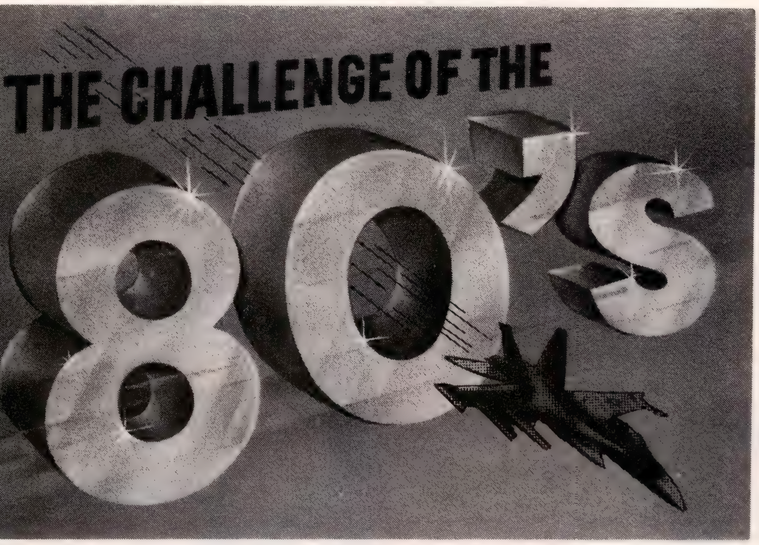

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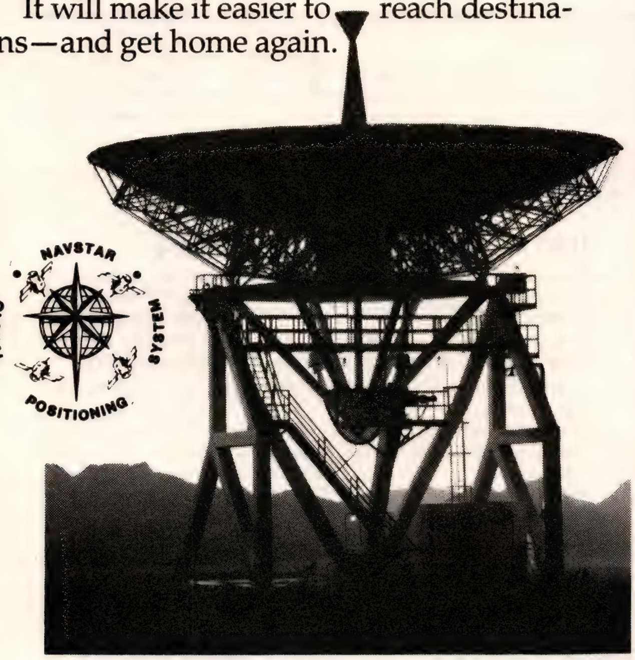

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- Provide the technical coordination required during implementation to maintain system, subsystem conceptual integrity
- Provide detail design and implementation direction to programmers

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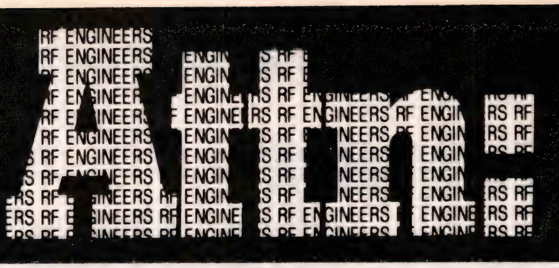

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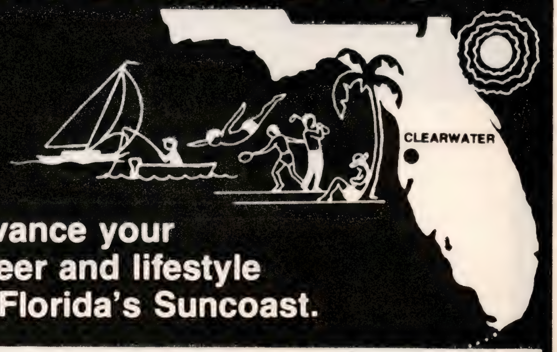

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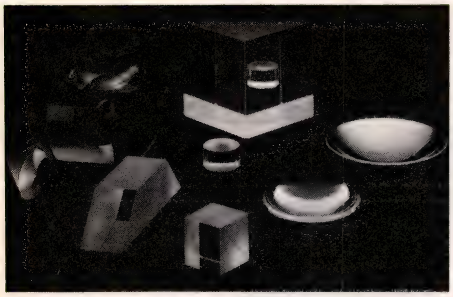

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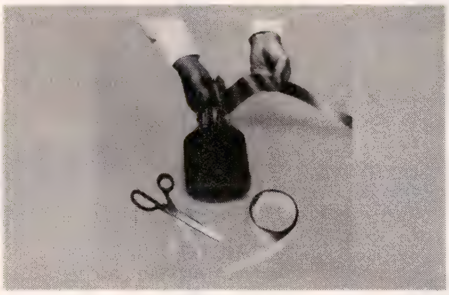

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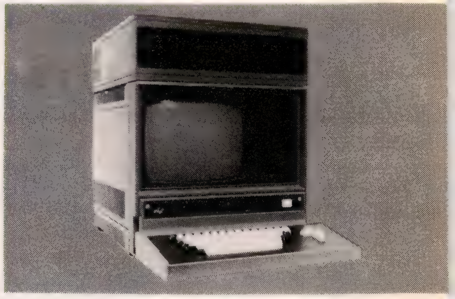

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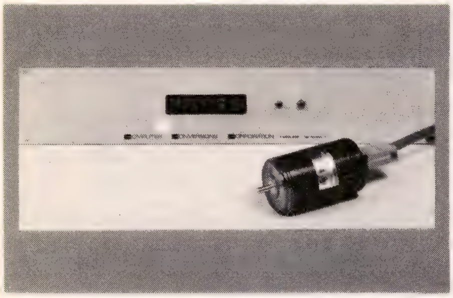

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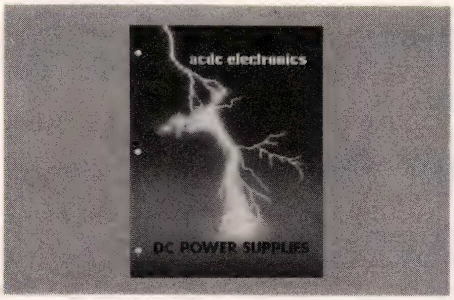

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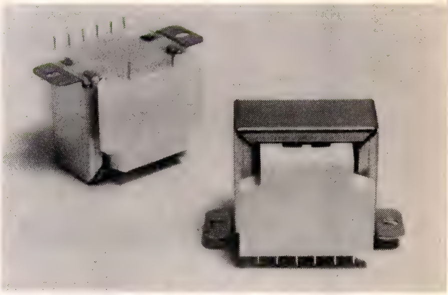

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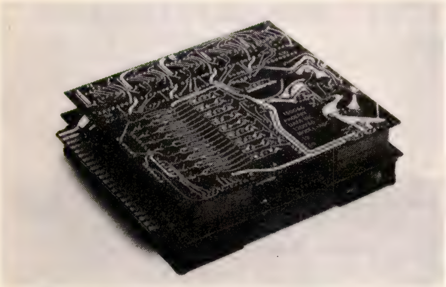

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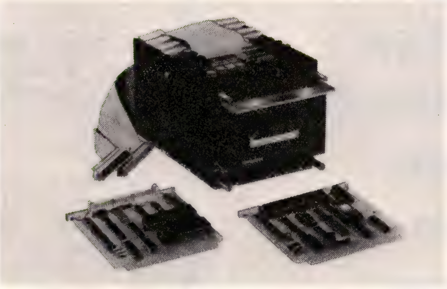

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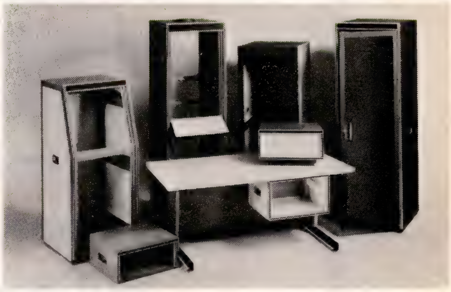

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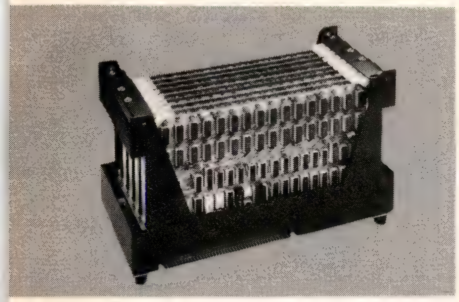

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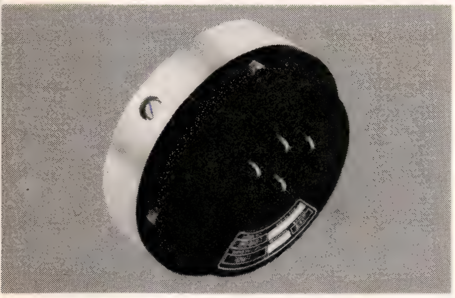

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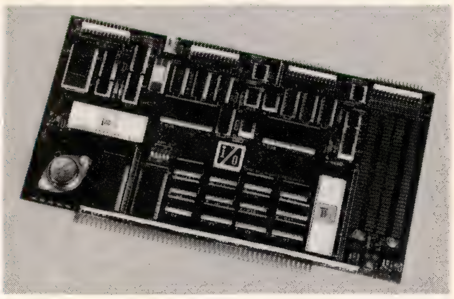

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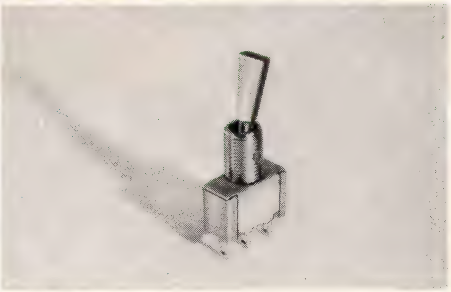

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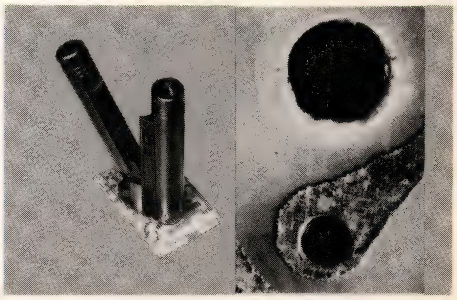

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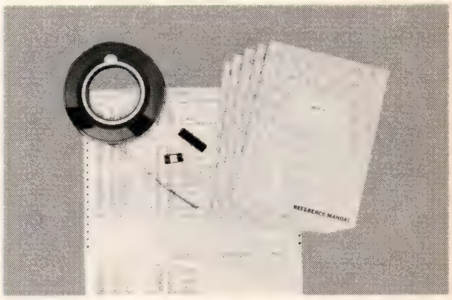

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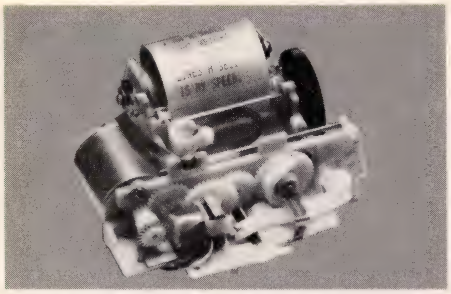

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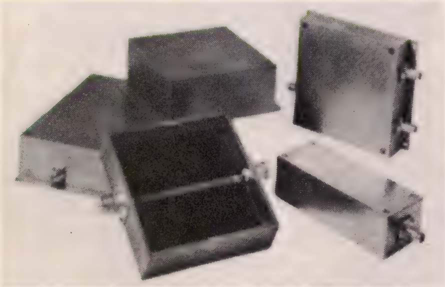

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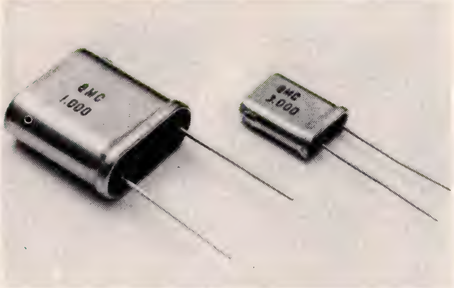

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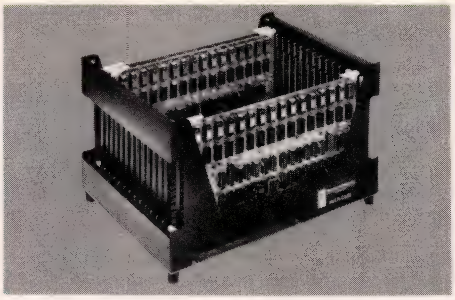

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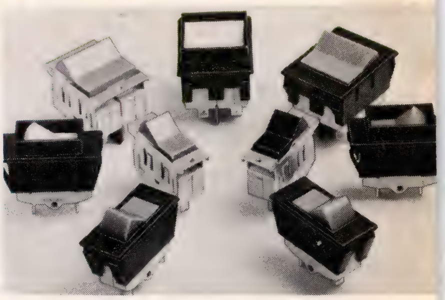

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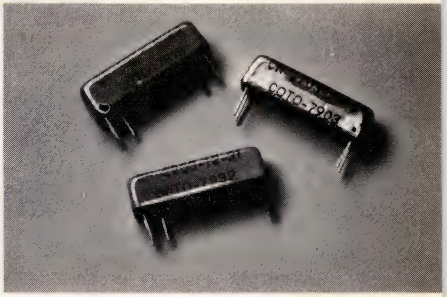

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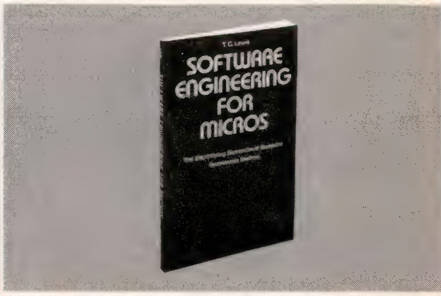

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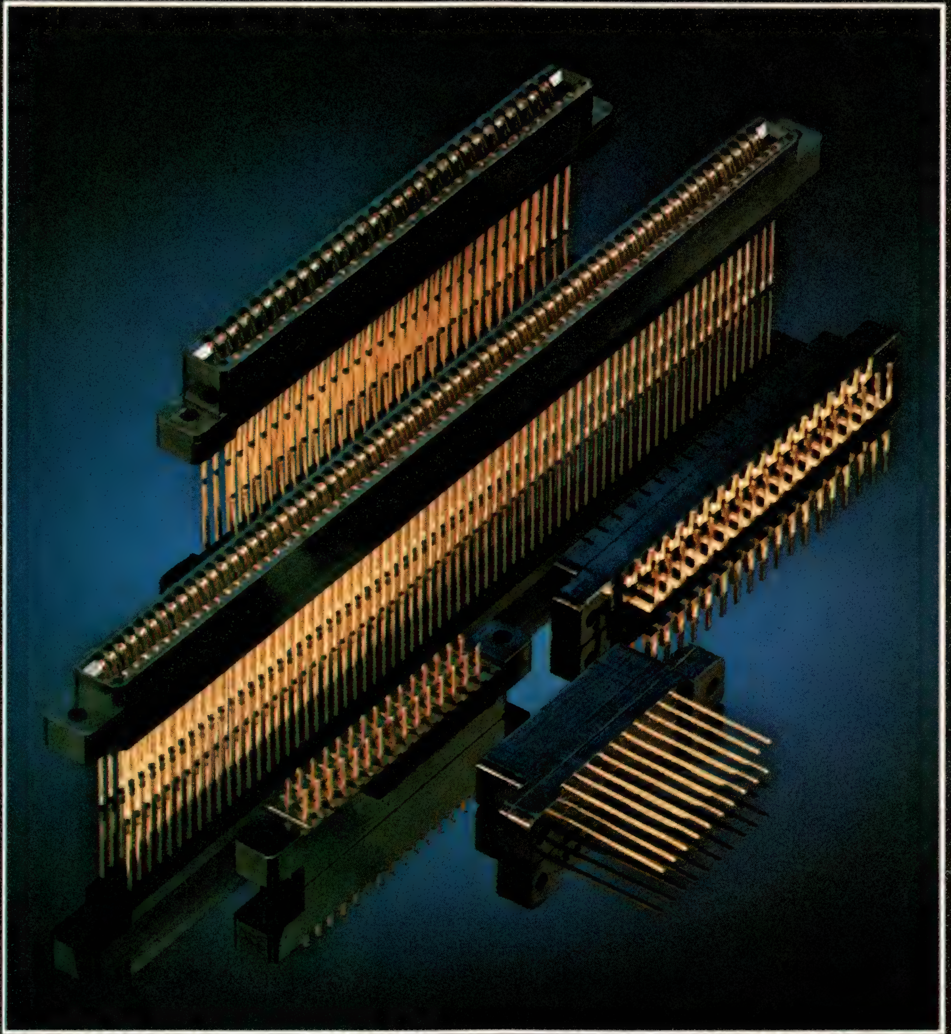

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CIRCLE 137

Index Of Advertisers

ACDC Electronics, Inc. 240
ADAC Corp. 179
AMP, Incorporated 102-103
AVX Ceramics Corporation *52H-I
Aavid Engineering Inc. 184
Acushnet Corporation .... †191
Advanced Micro Devices 6-7
AirBorn, Inc. 21
Alco Electronic Products, Inc. 182
Amphenol North America division
  Bunker Ramo Corporation 198-199
Amplifier Research Corporation 220
Analog Devices, Inc. 30, 222-223
Augat, Inc. 152-153
Austron, Inc. 228

B & K Precision 158, 159A-P
Beckman Instruments, Inc. 192, 193
Berg Electronics, Inc. 118
Bivar, Inc. .... †126A-B
Bodine Co., The 184
Bourns, Inc. .... Cover IV
Brand Rex Company 136
Bulova Watch Co. 226
Burndy Corporation .... †54-55

C & K Components, Inc. 241
CTS Corporation .... †128
CTS Knights, Inc. 246
Cambion 12, 13, 208
Canon U.S.A. Inc. 204
Centralab Inc. 58, 59
Chromatics Inc. 42, 43
Compac 242
Computer Automation, Inc. 61
Computer Conversions Inc. 240
Comstron Corp. 219
Coto Corp. 242
Crydom, Division of
  International Rectifier 22

Dale Electronics, Inc. 1
Data Precision Corporation 126
Datron Instruments Inc. 104
Dialight, A North American
  Philips Company 14
Dynetic Systems 246

ENI 168
E-T-A Circuits Breakers 242
Eagle Magnetics, Inc. 240
Eaton Corp., Cutler-Hammer 135
Electro Switch Corp. 208
Electronic Design 100-101*, 128,
  137, 138-139, 212
Electronic Development Corp. 109
Electronic Solutions 241, 242
Elfab Corp. 112
Exar Integrated Systems 44-45

Fairchild Test Systems 26-27
Ferranti Electric, Inc. .... †191
Forth, Inc. 133

G&H Technology, Inc. 206
G. R. Electronics Ltd. 246
GenRad 211
General Electric Company,
  Liquid Xtal Display Operations 229
General Electric Company,
  Semiconductor Products
  Department 159
General Instrument Corporation,
  Microelectronics Division 35
Gold Book, The 183
Gordos Arkansas, Inc. 213
Gould, Inc., Instruments
  Division 169, 171, 208
Greenray Industries, Inc. 182
Gulton Industries, Inc. 176

H.B.S. Equipment 242
Harting *52L
Hayden Book Company, Inc. .... †59
Hewlett-Packard 69-78
Hitachi Electronics Co., Ltd. 166-167
Humphrey, Inc. 241
Hycom 242

ILC Data Devices, Inc. 140
I/O Technology 241
ITT Cannon, A Division of International
  Telephone and Telegraph
  Corporation .... †197
Instrument Specialties Company. 186, 187
Integrated Circuits 190
Intel Corporation 10-11, 110-111
Interdesign 150-151
Interkama 149
Intertel, Inc. 25
Isotronics, Inc. 160
Italtel *52J

Jenson Tool Inc. *52K

Kepco, Inc. 48
Key Tronic Corp. 224
Keystone Carbon Company 41
Knowles Electronics 161
Kontron Electronics Inc. .... †53, 154

LeCroy Research Systems 200

Magnetics 183, 208
Memodyne Corporation 240
Mepco/Electra, Inc. 37
Metex Corporation 178
Microcomputer Rentals 240
Micro Switch, A Division
  of Honeywell 62
Mini-Circuits Laboratory, A
  Division of Scientific
  Components Corp. .... 8, Cover III
Mostek Corporation 89-94
Motorola Semiconductor Products,
  Inc. 207
MuRata Corporation of America .... †194

NEC Micro Computers, Inc. .... †56-57
National Semiconductor
  Corporation 17-20
Nichicon America Corporation .... †196

OK Machine & Tool Corporation 209
Optima Scientific Atlanta 172

Pan-Magnetics 240
Phoenix Data, Inc. 240
Philips CD/Elcoma *52B
Philips Test & Measuring
  Instruments, Inc. *52F
Piezo Technology, Inc. 226
Plessey Optoelectronics *52F
Power Hybrid Inc. 225
Power/Mate Corp. 39, 241
Power Products, Inc. 180
Premier Metal Products Company 240
Pro-Log Corporation 157

Q-Matic Corp. 242

Raymond Engineering Inc. 217
Rhombus Industries, Inc. 156
Rogers Corporation 241
Rolyn Optics 240

Sealectro Corporation 181
Seco Systems 241
Shugart Associates 84, 231
Skan-A-Matic 246
Siemens Corporation .... †52
Signetics Corporation, Analog Div. 163
Socapex 170
Spectral Dynamics Corporation 227
Spirig 241
Sprague Electric Company 177, 242
Stanford Applied Engineering 183
Standard Microsystems, Corp. .... Cover II

TRW Inductive Products 189
TRW Optron, A Div. of TRW 15
TRW/IRC Resistors, an operation
  of TRW Electronic Components. 116-117
TSRW/LSI Products 173
TEAC Corp. *52E
Tektronix, Inc. 51, 214-215, 245
Teledyne Relays, A Teledyne Company. 4
Texas Instruments,
  Incorporated 46-47, 100-101, 127,
  165, 185
Times Fiber Communications 221
Titchener & Co., E.H. .... †195
Toshiba America .... †60

Unimax Switch Corporation 216
Union Carbide Corp. 205
Union Carbide, Electronics Div.,
  Components Department 28-29
Vector Electronics Co., Inc. 210
Verbatim Corp. 175
Vero Electronics, Inc. 162
Viking Connectors, Inc. 243

Wakefield Engineering, Inc., EG&G. 204
Wells Electronics Inc. 202
Western Digital Corporation 201
Wiltron Company 203
Wintek Corporation 241

RECRUITMENT
Beall Personnell 237
GTE Sylvania, Inc. 238
Harris Corporation, Government
  Communications Systems
  Division 233
Harris Corporation, RF
  Communication Division 236
Link A Vision of the Singer
  Corporation 234
Litton Systems, Inc.,
  Amecom Division 236
Northrop Corporation,
  Drfences Systems Division 239
Northrop Corporation,
  Drfences Systems Division 232
Sperry Microwaves Electronics 237
Tracor, Inc. 235
Tektronix, Inc. 245
Westinghouse 237

†Advertisers in U.S. Edition
*Advertisers in Non U.S. Edition

The General Electric Co. advertisement for GE-MOV II varistors that appeared on page 271 in the June 7, 1980 issue of *Electronic Design* contained incorrect pricing information. Please see the advertisement on page 159 of this issue for correct pricing.

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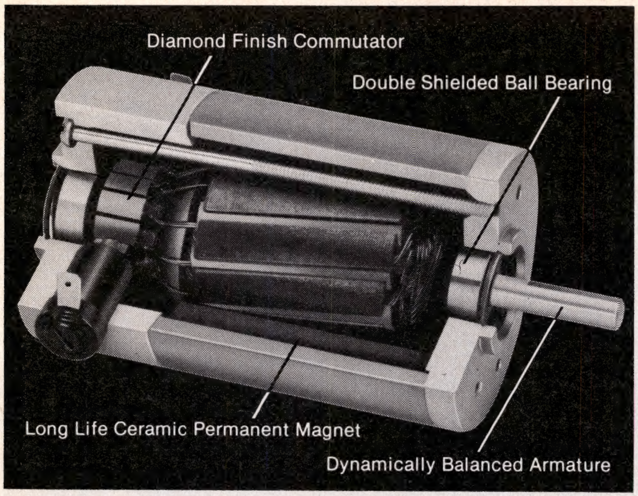
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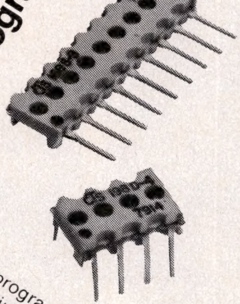

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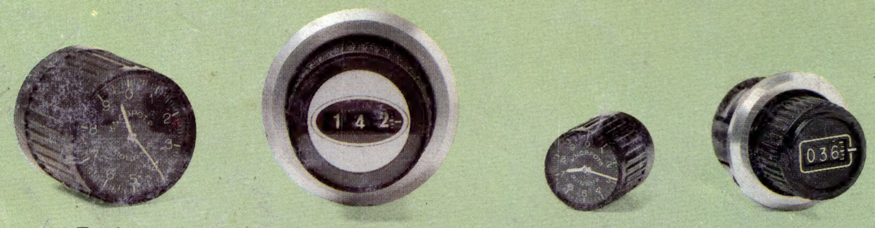

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